BEFORE THE NORTH DAKOTA DEPARTMENT OF HEALTH

IN THE MATTER OF:

PROPOSED DETERMINATION OF THE ADEQUACY OF THE NORTH DAKOTA STATE IMPLEMENTATION PLAN TO PREVENT SIGNIFICANT DETERIORATION

HEARING OF JUNE 12-13, 2003

POST-HEARING COMMENTS TO THE NORTH DAKOTA DEPARTMENT OF HEALTH, AND

COMMENTS ON EPA REGION 8'S MAY 2003 MODELING OF CLASS I SO_2 INCREMENT CONSUMPTION

SUBMITTED BY BASIN ELECTRIC POWER COOPERATIVE AND DAKOTA GASIFICATION COMPANY

Basin Electric Power Cooperative ("Basin Electric" or "Basin") and Dakota Gasification Company ("DGC") hereby submit the following comments to the North Dakota Department of Health ("NDDH" or "Department") and EPA Region 8.

These comments serve both as post-hearing comments to the NDDH regarding the hearing of June 12-13, 2003 in the above-captioned matter, and as comments on EPA Region 8's May 2003 Modeling of Class I SO_2 Increment Consumption in North Dakota and Eastern Montana, responding to Region 8's Federal Register notice and request for comments published on May 23, 2003.

Submitted herewith to the NDDH are six volumes of evidentiary material, two compact disks (with ENSR's modeling files for a June 2003 report and a wind tower study) to be included in the Department's administrative record and considered by the Hearing Officer respecting the hearing of June 12-13, 2003. Submitted herewith to

EPA Region 8 are the same six volumes of evidentiary material and the same two compact disks, together with three boxes of evidentiary material consisting of a copy of the NDDH administrative record for the hearing held on May 6-8, 2002 regarding the Adequacy of the North Dakota State Implementation Plan to Prevent Significant Deterioration.

I. INTRODUCTION

The sole question for the NDDH and EPA Region 8 is whether PSD Class I SO_2 increments are being violated in Class I areas in North Dakota or eastern Montana. This is important because: (1) it tells us about the state of air quality in the Class I areas; (2) it determines whether or not the State of North Dakota must require sources in North Dakota to install very expensive control equipment to reduce emissions of SO_2; and (3) it could have a major effect on the State's economy and future economic development in North Dakota. Sections I.A. through I.G. summarize the issues, evidence and authorities that are presented in these comments.

A. Monitoring Evidence

The best evidence of whether increments are violated is the 23 years of directly measured SO_2 concentrations at two monitoring sites in Theodore Roosevelt National Park ("TRNP"). This evidence shows that over this lengthy period there have been no increases in SO_2 concentrations in the South Unit of the TRNP, while concentrations in the North Unit have decreased. An examination of this data should be all that is needed to answer the question at issue. Nonetheless, EPA appears to have ignored this best evidence of increment consumption, and chosen to rely almost exclusively on air quality dispersion modeling of SO_2 increment consumption. We contend EPA's failure

to seriously consider this data, and reconcile the discrepancies between this date and EPA's modeling, cannot be justified.

B. NDDH and EPA Modeling

The EPA's May 2003 modeling concludes SO_2 increments are violated. The North Dakota Department of Health (NDDH or Department), based on modeling in 2003, concludes there is no violation. The Department also held a hearing on June 12-13, 2003 to further review its conclusion. We await the Department's determination based on that hearing. The different conclusions released thus far by EPA and the State rely on disparate meteorological and emission inputs to their respective modeling runs, as well as different legal interpretations.

C. Basin's Modeling

Basin has undertaken an in-depth evaluation of the work done by both EPA and the State, and attempted to perform an objective, clear-eyed assessment of both. In the process, we have identified and assembled what we believe to be the meteorological and emissions data that best parallels what actually has happened in the real world, and therefore results in modeling outcomes that best reflect actual Class I SO_2 increment consumption. In comparison, the meteorological and emission inputs used by EPA are, in several important respects, inaccurate and do not realistically reflect real-world facts or conditions. When Basin's superior data is input to the same Calpuff model used by EPA and the State, the model shows there are no violations of Class I SO_2 increments.

In doing this work, Basin used some of the same model inputs as the State, some of the same inputs as EPA, and some inputs used by neither the State nor EPA. Because we reach the same conclusion as the State, these comments do not dwell at length on

our differences with the State. Our focus will be on differences with EPA, because our conclusion is different than EPA's.

D. Basin's Modeling Uses Mostly the Same Inputs as EPA

For the purpose of its latest modeling, the results of which are submitted herewith, Basin has attempted to minimize the areas of disagreement with EPA. Therefore, we used the same inputs as EPA did on several points of controversy between the State and EPA, even though we appreciate there may be merit to the State's position.

E. Basin Uses Different Model Inputs Than EPA Where Basin's Information and Analysis Are Superior

We have used different model inputs than EPA only on those few points where we are convinced that our data and analysis are demonstrably and compellingly better than EPA's – they are more accurate, more reliable, better reflect reality, and/or have a stronger legal basis. As to those few points, we believe EPA's positions are not supported by the evidence in the record or by sound legal analysis. Our reasons for differing with EPA on these issues is explained at length herein.

F. Focus on 24-Hour Increment

Because the 24-hour SO_2 increment is the most constraining, EPA's May 2003 modeling focused on the 24-hour increment, rather than the 3-hour or annual increments. Basin likewise focuses on the 24-hour increment.

G. Other Issues

In these comments, we also raise two other issues: (1) that EPA, notwithstanding its commitment to do so in the late 1970s, has never adopted rules to govern a situation like this – where increment compliance is assessed outside of a PSD

permitting context. We believe that before it proceeds further, it is essential that EPA adopt such rules; (2) that because the State of North Dakota operates a PSD program that has been approved by EPA, the State has the first and primary responsibility and authority to determine whether there is compliance with Class I increments. Therefore, before EPA may make a finding contrary to the State's finding of compliance, EPA would have to establish that the State's findings are arbitrary or capricious, or contrary to law, or not supported by the evidence.

II. EPA SHOULD NOT PROCEED FURTHER UNTIL IT ADOPTS RULES TO GOVERN CASES SUCH AS THIS

The purpose of the modeling conducted by EPA Region 8 and the NDDH, and related proceedings, is to determine whether Class I SO_2 increments are violated as a result of emissions from existing sources. There are no regulations to govern this situation. EPA's regulations covering compliance with PSD increments and other PSD requirements are found at 40 C.F.R. § 51.166. These regulations, specifically including Sections 51.166(i) through (q), specify what is required to *permit* a new major source or major modification. They include provisions respecting increment compliance and increment variances for *permitting* purposes. However, nothing in the regulations instructs us how to proceed outside of the permitting context.

In *Alabama Power v. Costle*, 363 F.2d 323, 361-63 (D.Cir. 1979) the court rejected industry arguments that the PSD permitting process was the sole vehicle for protecting PSD increments, and held that states had a broader duty to protect increments. The court confirmed EPA's right to require, outside the permitting process, that States "make provision to ensure that violations of the increments of maximum allowable concentrations do not occur, and, if they have occurred, to ensure that steps

will be taken to correct the violation." *Id.* The court went on to acknowledge that "*EPA has furnished no guidelines to the states in this regard . . . .* Industry evidences a concern that when EPA does promulgate guidelines or require specific measures, certain operating facilities will be unfairly disadvantaged. . . . *At oral argument, EPA assured the court that any such measures would be employed in a reasonable fashion on the basis of a rule of general applicability, or by some reasonable attribution of responsibility for the violation. Any regulations promulgated will be reviewed with such considerations in mind.*" (Emphasis added) *Id.*

More than 20 years after *Alabama Power*, EPA has yet to promulgate the promised regulations for the non-permitting context. Basin submits it is essential that such rules be promulgated before anyone proceeds further in these circumstances. In the absence of such regulations, there are uncertainties as to what the rules are. For example, should we assume that the variance provisions of Section 51.166(p), which apply by their terms only in a permitting context, also apply to this case? Would existing sources, individually or collectively, be authorized to apply for a variance if it were finally concluded SO_2 increments are violated? The regulations are silent on this issue, but there does not appear to be any reason why variances should not be available, as long as AQRVs are not adversely impacted, even if increment violations were found. In the absence of regulations, however, we are left with no certainty about what the rule is. If an increment violation were found, and an application for a variance were made to the FLM, would the FLM know what to do? In matters as weighty as this, with potentially hundreds of millions of dollars at stake, it is not prudent or appropriate for this matter to proceed in the absence of rules.

EPA assured the court in *Alabama Power* that it intended to promulgate a rule of general applicability, but it has not done so. It is premature for EPA or the NDDH to proceed further until such a rule is adopted.

III. MONITORING DATA

EPA focuses virtually exclusively on air quality dispersion modeling and what modeling tells us about increment consumption. This focus on modeling ignores the 23 years of data on actual measurements of SO_2 concentrations from monitoring equipment in the Class I areas, specifically in the North and South Units of Theodore Roosevelt National Park. The monitoring equipment is reliable, and the measured data is quality assured and incorporated in EPA's AIRS database. There appears to be no dispute as to the validity of this data.

This data shows that SO_2 concentrations in the North and South Units of TRNP have either decreased over the past 23 years (North Unit) or remained stable and not increased (South Unit). Figures 1 and 2 are graphic illustrations of the second high 24-hour values in the TRNP North and South Units for the years 1980 through 2002. This information is included in the record of the 2002 and 2003 NDDH hearings on Class I SO_2 increment consumption.

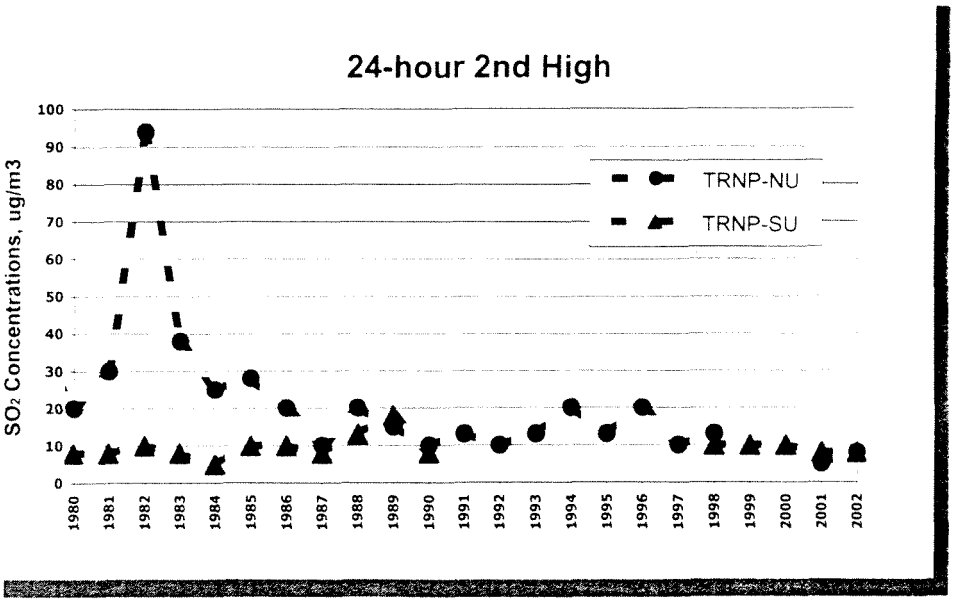

Figure 1

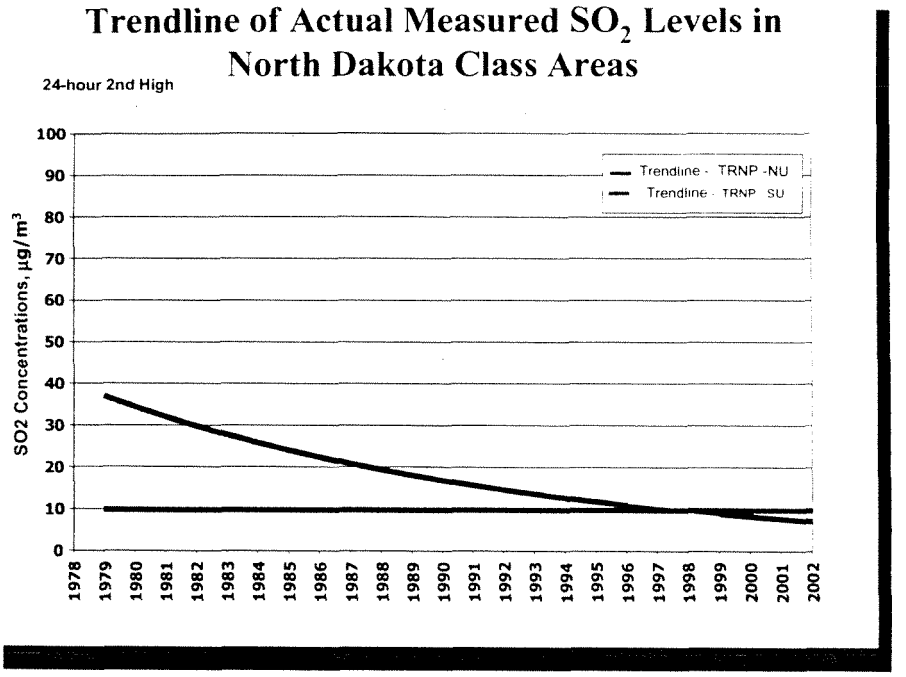

Figure 2

Also, the National Park Service, in its report, Air Quality in the National Parks, Second Edition, found that sulfate ion concentrations and deposition, which are related to sulfur dioxide, have improved in the TRNP over the past decade. A copy of excerpted text from this report is appended as Attachment A. Given that the only directly measured empirical evidence demonstrates that there has been no increase in SO_2 concentrations, most people would conclude that there are no Class I increment violations and let the matter rest.

However, despite the fact that observed data shows no increase in SO_2 concentrations, EPA has chosen to perform computer dispersion modeling. EPA's modeling shows apparent violations of Class I SO_2 increments. EPA evidently has chosen to rely exclusively on the model results, and to ignore the observed data. Basin submits that it is not reasonable or justifiable for EPA to ignore the actual measurements of SO_2 concentrations in Class I areas, and that before EPA reasonably could rely on its modeled predictions, the agency would need to account for and reconcile the discrepancies between the observed and modeled data. EPA must "back up" its modeling "with checks against real world data." *State of Ohio v. EPA*, 784 F.2d 224, 230 (6th Cir. 1986). Such checks are especially important when dealing with air quality dispersion models, the accuracy of which generally is accepted, observed the court, if it is within a factor of 2, "a 200% deviation from actual fact." 784 F.2d at 229. The court held that

> EPA's reliance on the CRSTER model without testing the model against any monitored emissions from the plants and ambient air quality data from the area around the plants is arbitrary and capricious under these circumstances. . . . In

> the absence of a record supporting the trustworthiness of agency decision-making tools as they were applied, we cannot uphold those tools' application.

Id. at 230.

In *PPG Industries v. Costle*, 630 F.2d 462, 468 (6th Cir. 1980), the court held the record did not support the use of EPA's modeling, and recognized that monitored data is relevant where it tends to show the agency's predictions are not supportable.

Monitoring of air quality is an important feature of the Clean Air Act. Under the Act, each state is required to establish an air quality monitoring system as part of its State Implementation Plan ("SIP"), and EPA is required to establish a supplemental monitoring system throughout the country. 42 U.S.C. §§ 7410(a)(2) and 7619. "These State and national air quality monitoring systems provide the critical information for purposes of defining 'non-attainment' with the National Ambient Air Quality Standards (NAAQS), evaluating progress to work achievement of the NAAQS pursuant to SIPs, and reporting air quality data to EPA to document the status and trends of the nation's air quality." 59 Fed. Reg. 41626 (Aug. 12, 1994). If monitoring is an acceptable means to obtain critical information regarding attainment of the NAAQS, which are health-based standards designed to prevent harm to people, does it not follow that monitoring should be an acceptable means of obtaining information to assess compliance with PSD increments, which have no impact on health?

In the EPA Comments on North Dakota Department of Health's Proposed Determination Regarding the Adequacy of the SIP to Protect PSD Increments for Sulfer Dioxide, dated May 24, 2002, ("EPA Comments"), the agency attempted to debunk the value of the 23 years of observed data in order to justify its reliance on modeling. We will discuss the EPA Comments, but before doing so, we will briefly outline some of

the limitations of air quality dispersion modeling. A modeled prediction is, after all, merely a computerized estimate of the behavior of SO_2 emissions after they are released to the atmosphere, the accuracy of which is limited by uncertainties regarding emission rates and meteorological conditions that are input to the model, as well as the imperfect capability of computer algorithms to mimic the real world.

A. Limitations of computerized air quality dispersion modeling.

Notwithstanding their limitations, computer models can be useful tools if used properly and if their limitations are acknowledged and understood. When a new source is proposed, for example, there is no measured data demonstrating the impact of the not-yet-built source, so modeling is the best we can do. However, in North Dakota we are not permitting a proposed source and we do have actual data demonstrating the impact of existing sources.

EPA's Guideline on Air Quality Models, 40 CFR Part 51, Appendix W ("Guideline"), clearly acknowledges that air quality dispersion models are imperfect tools:

> (1) "*Air quality models* have been applied with the *most accuracy* or the *least degree of uncertainty* to *simulations* of *long-term averages in areas with relatively simple topography. Areas subject to major topographic influences experience meteorological complexity that are extremely difficult to simulate.* Although models are available for such circumstances, they are frequently site specific and resource intensive. *In the absence of a model capable of simulating such complexities, only a preliminary approximation may be feasible until such time as better models become available.*" (Emphasis added). *Guideline*, Section 2.1.b.
>
> (2) "*A model applied* improperly, or *with inappropriately chosen data*, can lead to *serious misjudgments regarding the source impact* or the effectiveness of a control strategy." (Emphasis added). *Guideline*, Section 2.1.c.

(3) "A number of studies have been conducted to examine model accuracy, particularly with respect to the reliability of short-term concentrations required for ambient standard and increment evaluations. The results of these studies are not surprising. Basically, they confirm what expert atmospheric scientists have said for some time: (1) *models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations*; and (2) the models are *reasonably reliable* in *estimating* the magnitude of *highest concentration* occurring *sometime, somewhere within an area.* For example, *errors in highest estimated concentrations of ± 10 to 40 percent are found to be typical, i.e., certainly well within the often quoted factor-of-two accuracy that has long been recognized for these models. However, estimates of concentrations that occur at a specific time and site are poorly correlated with actual observed concentrations and are much less reliable.*" (Emphasis added). *Guideline*, Section 10.1.2.a.

Thus, EPA has told us several significant things about air quality dispersion models: (1) they are less reliable in estimating short-term concentrations such as the 24-hour concentrations at issue in North Dakota; (2) with complex meteorology, unless one uses a model capable of simulating such complexity, only a preliminary approximation of ambient concentrations may be feasible; (3) inaccurate data inputs to a model can lead to serious misjudgments; (4) models cannot reliably predict concentrations at specific times and places; and (5) even with a perfect model, used for the far less rigorous task of predicting a high concentration in a general area, they are subject to inherent errors.

Because in this case the 24-hour SO_2 increment is only 5 micrograms/cubic meter, or less than 2% of the 24-hour SO_2 NAAQS, a modeling error of only 5 micrograms/cubic meter could all by itself account for a modeled "violation." But under EPA's traditional measure of acceptable model accuracy, i.e., a model is OK if accurate within a factor of 2, a 5 microgram *error* would be deemed acceptable in this

case. Thus, it is possible that actual increases in Class I SO_2 concentrations could be *zero*, but an acceptable model error could still predict "violations."

These model limitations and uncertainties suggest strongly a need to test modeled results against actual measured data to avoid possibly erroneous modeling conclusions. In this case, where 23 years of direct observations indicate there has been no increase in Class I SO_2 concentrations, EPA modeling that predicts numerous violations of Class I SO_2 increments should be viewed with extreme caution, and subjected to severe scrutiny. These model results should not be considered valid or relied on for regulatory purposes unless EPA can explain satisfactorily why model results are so markedly different than observed values.

B. EPA Attempts to Debunk the Importance of Monitored Data

In its May 24, 2002 Comments on North Dakota Department of Health's Proposed Determination Regarding the Adequacy of the SIP to Protect PSD Increments for Sulfur Dioxide, (EPA Comments), at page 8, EPA Region 8 said it "generally considers monitoring data unreliable for determining how much of the increment has been used up," but the explanations it offers do not support its position. The following are EPA's explanations for rejecting monitoring data, and Basin's responses.

Explanation 1. EPA says: "[T]he year-to-year variability of air quality data limits the usefulness of certain data collected. For example, by looking at monitoring data alone one cannot distinguish concentration peaks caused by emission increases from those related to meteorological variations."

Basin responds: This is a non sequitur. Increments are defined as a maximum allowable increase in ambient concentration over a baseline concentration. If observed data shows there is no increase over ambient baseline concentrations, there

can be no increment consumption. In this context, the relative effects of emissions and meteorology on ambient concentrations are irrelevant.

Explanation 2. EPA says: "[M]onitoring data will include not only 'increment consuming' source emissions . . . but also emissions from non-increment consuming sources and background level pollution."

Basin responds: Where ambient concentrations have not increased, it is not necessary to determine which portion of increases might or might not be increment consuming because there are no increases at all.

Explanation 3. EPA says: "[I]t is not practical to have monitors in all locations where elevated concentrations of pollutants may threaten PSD increment."

Basin responds: While it is true that monitors are not everywhere, the location of monitors are selected to be representative of high concentrations. *See* 40 C.F.R. Part 58, App. D. Also, EPA provides no explanation of why, across a span of many years, with the full range of meteorological variations occurring in those years, there would tend to be concentrations elsewhere in the park that might have been significantly higher than those at the monitoring sites. It is not plausible that over several years the monitoring sites would uniquely have been shielded from conditions that would result in higher concentrations at other locations in the park.

ENSR recently has done a study entitled Representativeness of SO_2 Monitoring Data at Theodore Roosevelt National Park ("Receptor Study"), a copy of which is submitted herewith. Peak values modeled by EPA and ENSR at receptors in the TRNP are plotted, and the plots show that, indeed, high modeled values tend to be at receptors

very near the monitoring sites. This reinforces the fact that SO_2 concentrations at the monitoring sites are, in fact, representative of high concentrations anywhere in the park.

Explanation 4. EPA says: "[M]odels have the advantage of being able to predict pollutant and PSD increment concentrations at locations where siting of monitors may not be possible."

Basin responds: It is true that monitors are not everywhere, but as noted above, EPA cannot explain why observed concentrations at the monitoring sites over 23 years would not be representative of high values throughout the park. In fact, ENSR's Receptor Study shows they are representative. Moreover, model results do not improve our level of knowledge if they are based on flawed inputs and cannot be reconciled with observed concentrations.

Explanation 5. EPA says: "[D]ue to the lack of an adequate number of monitors, in the early years of the PSD program (during the time period the baseline was established), if the program were to rely on monitoring it would make calculating baseline (and other aspects of the PSD program) virtually unworkable."

Basin responds: This is another non sequitur. We do not suggest that *only* monitoring can be used to determine baseline concentrations or that other methods cannot be used where necessary and appropriate. We submit only that *where there is pertinent monitored data*, EPA may not conveniently ignore that data, as if it did not exist.

Explanation 6. EPA says: "[M]onitoring data collected at a single location is not representative of concentrations that may occur at other nearby Class I receptors because SO_2 concentrations can vary greatly over small distances."

Basin responds: Although it may be true that concentrations at one location may not be representative of nearby concentrations *on that same day*, certainly over the course of many years there are sufficient variations in meteorology that the highest concentrations at the monitoring sites would be representative of the highest concentrations elsewhere in the park. *See also*, ENSR Receptor Study.

Explanation 7. Finally, EPA says that local oil and gas production sources significantly influence monitoring concentrations, and that oil and gas production and SO_2 concentrations are positively correlated. From this, EPA argues that State records show oil production in the late-1970s baseline period was lower than in 1980, and that SO_2 concentrations in the baseline period also must have been correspondingly lower. EPA contends that "[t]his is suggestive of possible increment consumption."

Basin responds: EPA's speculation has no basis in fact. As this case demonstrates, there is no direct correlation between oil production and SO_2 emissions. As noted in the NDDH's Prevention of Significant Deterioration; Sulfur Dioxide, Final Baseline Emission Rates, May 2003, pages 90-102, the gas from many oil wells was being flared in the late 1970's, thereby producing SO_2, whereas by the early-to mid-1980s, much of the previously flared gas was being collected and sold, and therefore was not producing SO_2. Also, records of gas production (as distinguished from oil production) were not reliable prior to 1987 because before it was routinely gathered and sold, gas was not regarded as a high value product to which a great deal of attention was paid. Moreover, there is no evidence that the ratio of natural gas production to oil production remained constant from well to well or year to year. Finally, EPA's repeated public statements to the press in 2003 have attributed the alleged problem with

increment consumption to emissions from the major coal-fired power plants in North Dakota, emissions that EPA asserts must be reduced by 60,000 to 75,000 tons to comply with Class I increments. These statements contradict EPA's contention in 2002 that it was oil and gas production sources that primarily accounted for ambient SO_2 concentrations.

The EPA Comments also cite 43 Fed. Reg. 26380, 26399 (June 19, 1978) as authority for generally considering monitoring data unreliable for determining increment consumption. However, the policy announced in the cited text (not to require preconstruction monitoring for PSD permits) was subsequently invalidated in *Alabama Power v. Costle*, 63 F.2d 370, 371-373 (D.C. Cir. 1979). Additionally, the cited text did not dismiss the value of monitoring, but instead stated "EPA does not intend that there be no 'real world' checks on the accuracy of modeling." 43 Fed. Reg. at 26399.

Finally, EPA's Comments also cite Section 1.0.b of 40 CFR Part 51, App. W, for the proposition that monitoring is deemed unreliable for determining increment consumption. But Section 1.0.b does not say that. It says, rather, that monitoring data normally are not sufficient as the *sole basis* for demonstrating the adequacy of emission limits. The cited section goes on to say that air quality measurement can be used in a complementary manner to dispersion models, with due regard for the strengths and weaknesses of both analysis techniques and that "[m]easurements are particularly useful in assessing the accuracy of model estimates." Basin concurs that TRNP monitoring data are particularly useful in this case as a check on erroneous modeling conclusions, and urges the EPA to consider the corrections to its modeling urged by Basin, in order to conform modeling results more closely to observed concentrations.

C. Why It Is Necessary and Appropriate to Use Monitoring Data to As a Reality Check on EPA's Flawed Modeling

Under the Clear Air Act, increment consumption must be determined based on "available air quality data". Section 169(4) of the Act defines baseline concentration as

> "The ambient concentration levels which exist at the time of the first application for a [PSD] permit in an area subject to [PSD], based on air quality data available in the Environmental Protection Agency or a state pollution control agency and on such monitoring as the permit applicant is required to submit."

The Senate explained what this meant: "[T]he purpose is to use actual air quality data to establish the baseline. Where sufficient actual data are not available, the State may require the applicant to perform whatever monitoring the State believes is necessary to provide that information." S. Rep. No. 127, 95th Cong., 1st Sess. 98 (1977), quoted in *Alabama Power v. Costle*, 636 F.2d 323, 375-76 (D.C. Cir. 1979).

In *Alabama Power* the Court considered the following language from Section 165(e)(2) of the CAA:

> "The *analysis required* [for a PSD permit] *shall include the continuous air quality monitoring data* gathered *for purposes of determining whether emissions* from such facility *will exceed* the maximum allowable increases on *the maximum allowable concentration permitted under this part*." (Emphasis added.)

42 U.S.C. § 7475(e)(2)

The Court confirmed that,

> "This is a *plain requirement for inclusion of monitoring data, for purposes of the determination whether emissions will exceed allowable increments*." (Emphasis added.)

636 F.2d at 372.

The Court discerned that,

> "*Congress intended that monitoring would impose a certain discipline on the use of modeling techniques*, which would be the principal device relied upon for the projection of the impact on air quality of emissions from a regulated source. *This projects that the employment of modeling techniques be held to earth by a continual process of confirmation and reassessment, a process that enhances confidence in modeling as a means for realistic projection of air quality*. Though *EPA* has authority to require methods other than monitoring in its effort to ensure that allowable increments and NAAQS are not violated and though it may choose to invoke that authority because of its perception that monitoring alone is inadequate to the task, *it does not have authority to dispense with monitoring as at least one element of the overall enforcement effort where Congress has mandated the use of that technique*." (Emphasis added.)

636 F.2d at 372.

Further, when proposing the current PSD rules, EPA stated it

> "agrees that *monitored ambient data is valuable for such purposes as validating and refining models and, in some cases, providing a direct measure of increment consumption*. In accordance with the court's opinion [in *Alabama Power*] *EPA plans to place greater emphasis on the development and use of monitoring data*." (Emphasis added.)

44 Fed Reg. 51924, 51944 (Sept. 5, 1979).

Considering the importance placed on monitoring data by the Clean Air Act, the courts, implementing regulations, and EPA policy, it is difficult to understand why EPA in this case would attempt to disregard such data and rely exclusively on computer-modeled estimates of SO_2 concentrations--especially estimates that are inconsistent with actual measured concentrations.

Monitored data is based on direct measurements of tangible samples of actual air in the Class I areas. Modeled predictions in this case, by comparison, are not based on tangible hard data but rather on imperfect algorithms, limited knowledge of the weather conditions, and guesstimates of baseline emissions.

Not only are EPA's modeled results inherently less reliable than direct measurements when viewed in the context of actual data, they appear to be anomalous. Mr. Robert Connery, in his testimony before the NDDH on June 12-13, pointed out that in 2002 the second high 24-hour measured concentrations of SO_2 in the TRNP North and South Units was approximately 8 micrograms/cubic meter in 2002. The Class I 24-hour SO_2 increment is 5 micrograms/cubic meter. Therefore, in order for the increment to be exceeded, the baseline 24-hour second high concentration would have to be 3 micrograms/cubic meter or less. Figure 3 is a graphic illustration of Mr. Connery's point.

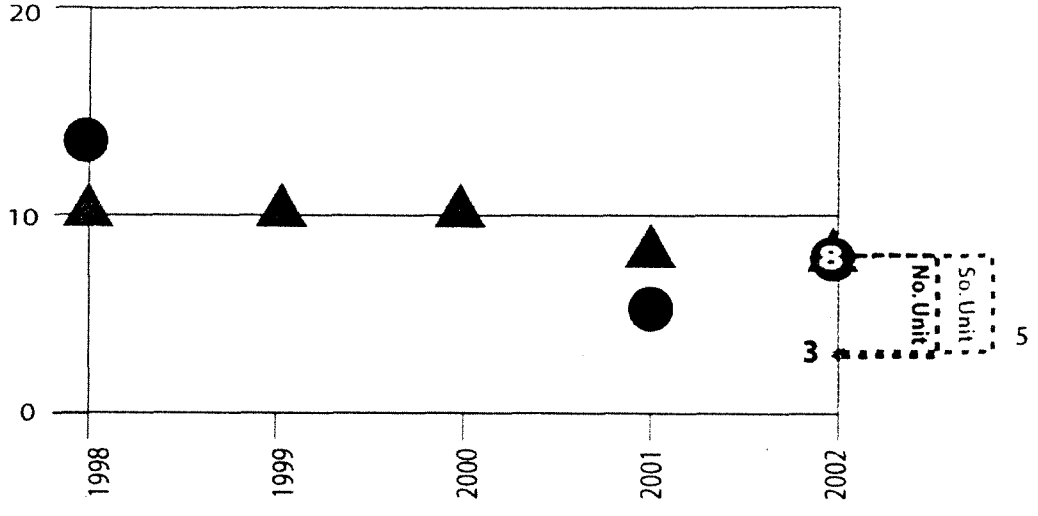

Figure 3

Mr. Connery went on to point out that EPA modeling predicts that, based on second-high 24-hour concentrations, 10.5 micrograms/cubic meter of increment has been consumed in the South Unit, and 11 micrograms/cubic meter has been consumed in the North Unit. Considering that measured 2002 second high 24-hour values were 8 micrograms/cubic meter, for EPA's predictions to be accurate, baseline concentrations would have to have been *less than zero* – minus 2.5 micrograms and

minus 3.0 micrograms at the South and North Units, respectively. Figure 4 is a graphic depiction of this situation.

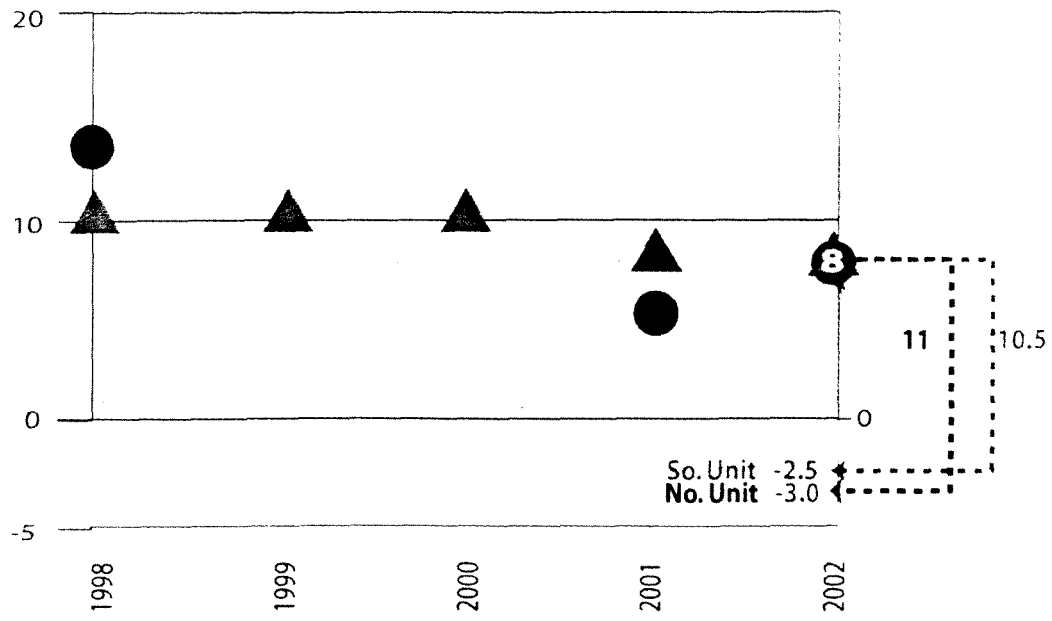

Figure 4

Of course, it is not possible that baseline concentrations could have been less than zero. The explanation for this anomaly is that EPA's model overstates the amount of increment consumed.

IV. MODELING

A. General

As noted above, Basin submits that the most sensible course of action in the circumstances of this case would be to acknowledge that 23 years of monitoring observations shows unequivocally that there are no increment violations, and simply accept that fact.

Nonetheless, not only has modeling been done in this case, it has emerged as the focal point of controversy. Therefore, Basin will discuss modeling in extensive detail.

Previously, the use of the Calpuff model was a point of contention, because until April 15, 2003, Calpuff was not an approved guideline model. However, Calpuff has now been approved as a preferred model for long-range transport. Therefore, Basin does not disagree with the use of Calpuff as the model of choice. Basin does disagree, however, with some of the meteorological and emissions data that EPA used to do its modeling. Unless model inputs are reasonably accurate and reasonably reflect what is happening in reality, a model easily can predict an apparent increment violation when, in fact, none exists. Basin submits that is precisely what EPA's modeling has done. Accurate inputs are of especially acute importance in the context of the extremely small PSD increments for SO_2. The 24-hour increment is 5 micrograms/cubic meter, or roughly *2 parts per billion*. This is barely over the 1 part per billion detection limit of the monitoring equipment in the TRNP. It is evident that even relatively small inaccuracies in the inputs to Calpuff could skew the model output enough to give a "false positive" reading.

B. Paired in Time and Space vs. the MAAL

The NDDH and EPA Region 8 apply different methods for determining increment consumption. To understand the difference, we first need to know how the modeling works. For a given year, a model uses 365 days of meteorological data. To model baseline concentrations, the model uses baseline emission rates with these 365 days of meteorological data. To model current concentrations, the model uses current emission rates with the same 365 days of data.

The Department's modeling first determines a second-highest baseline concentration for a single meteorological year (365 days of meteorological data), next determines a second-highest current concentration for that year, and takes the difference

as the amount of increment consumed. EPA Region 8's modeling determines the modeled baseline concentration for a single meteorological day, next determines the modeled current concentration for the same meteorological day, then takes the difference between the two. It does this for each of the 365 meteorological days in the year, and selects the second-highest daily difference as the amount of increment consumed. The NDDH designates its method as the Maximum Allowable Ambient Level, or "MAAL" method. We will refer to EPA's method as the paired-in-time-and-space or "paired" method.

In many cases, including cases where only a single source is modeled, the results of these two methods will be the same. However, in this case they are not, because there are not only many sources in many different locations, but some baseline sources have been shut down and some current sources were not operating during the baseline.

It may not be readily obvious to non-technical persons why the two methods would yield different results. Readers are referred to the oral and written testimony of Mr. Kirk Winges at the May 6-8, 2002 and June 12-13, 2003 hearings conducted by the NDDH, for a very understandable explanation and illustration of why they are different.

Understanding why they are different, however, does not answer the question which is the right method. Basin submits that the MAAL method is the one compelled by the Clean Air Act. Certainly, the MAAL method is fully consistent with the statute and regulations.

The effect of the MAAL method is to compare the second-high baseline concentration with the second-high current concentration. The effect of EPA's paired method is to compare the baseline and current concentrations day by day – the modeled

baseline concentration for meteorological day January 1 is compared with the modeled current concentration for meteorological day January 1; the modeled baseline concentration for January 2 is compared with the modeled current concentration for January 2; etc.

The Clean Air Act provides that

> each [State's] implementation plan shall contain measures assuring that *maximum allowable increases over baseline concentrations* of . . . each pollutant shall not be exceeded (emphasis added).

42 U.S.C. § 7473(a). For 24-hour periods, the maximum allowable increase, or increment, may be exceeded only once per year. *Id.* Thus, it is the second-highest concentration that is compared with the allowable increment.

The "baseline concentration" means

> "The ambient concentration levels which exist at the time of the first [PSD] application . . ., based on air quality data available in the Environmental Protection Agency or a State air pollution control agency and on such monitoring data as the permit applicant is required to submit. . . ."

42 U.S.C. § 7479(4).

EPA's regulations define "baseline concentration" as

> "That ambient concentration level that exists in the baseline area at the time of the minor source baseline date. A baseline concentration is determined for each pollutant for which a minor source baseline date is established . . ."

40 C.F.R. § 51.166(13)(1).

EPA's regulation, by its terms, anticipates there will be a determination of "a" single baseline concentration, as done by the NDDH, not 365 different daily baseline concentrations during a year, as done by Region 8. Only by establishing one baseline concentration can we possibly assess whether ambient levels of a pollutant have gotten

better or worse over time. In this case, EPA's method does not tell us whether air quality has improved or deteriorated over time, as explained in Mr. Winges' testimony. Mr. Winges provides an illustration of a case where a dirtier, more polluting baseline facility is shut down, and replaced by a cleaner, less polluting facility in a different location. Both facilities are near a Class I area, but the new facility is farther away. In this example, modeled concentrations in the Class I area from the new facility generally are much lower than modeled concentrations from the old facility. We would expect such a favorable outcome when a dirtier facility is replaced by a much cleaner one.

Anomalously, however, in this example EPA's method predicts an *increase* in ambient levels that exceed the allowed increment. This result defies common sense – how could EPA arrive at such a result? As explained by Mr. Winges, EPA's anomalous prediction results from the fact that EPA makes a day-by-day comparison. Even though current concentrations in the Class I area might be less than baseline concentrations on 360 days in the year, there might be five days when the wind blows from the new plant toward the Class I area and, because the shut-down old plant was in a different place, the model would give no credit on those five days for the old plant's shutdown, and give the erroneous impression that air quality had deteriorated. Essentially, because the model has "blinders" that only enables it to compare June 1st with June 1st, it cannot see the reality that ambient levels have greatly improved.

EPA justifies its method by reference to informal guidance from the early 1980s, and by quoting from its Guideline on Air Quality Models, 40 C.F.R. Part 51, App. W, Section 11.2.3.3.b:

> "sequential modeling must demonstrate that allowable increments are not exceeded temporally and spatially, i.e.,

> for all receptors for each time period throughout the year(s)."

However, nothing in this language provides that each baseline day should be separately compared with each current day. The language may be somewhat bureaucratically opaque, but it merely says modeling has to show increments are not exceeded for each time period throughout the year. That is precisely what NDDH's modeling does – it models *each day* in the baseline period to fix a baseline concentration; and it models *each day* in the current period to see if the increment is exceeded on any of those days.

Mr. Winges also illustrated that, in attempting to compare increment consumption on a day-by-day basis, paired in time and space, EPA is asking its model to do something it is not capable of doing – to predict concentrations at a specific time and place. EPA's Guideline on Air Quality Models, Section 10.1.2.a., admits that

> "estimates of concentrations that occur at a *specific time* and *site* are *poorly correlated* with *actual* observed *concentrations* and are much less reliable."

In his 2002 testimony, Mr. Winges provided a scatterplot comparing modeled Calpuff concentrations with observed concentrations at the same time and place, which confirmed the model, indeed, is absolutely incapable of predicting concentrations at a particular time and place.

Thus, when the model predicts a concentration on a specific day, we know the prediction is not reliable. But for EPA's method to work, the model's prediction for a specific baseline emission day would have to be accurate, so it could be compared to the same current emission day. EPA's method, therefore, not only conflicts with the statute, the regulations and basic common sense, it generates results that are inherently unreliable.

It is important to ask the basic common sense question, what is the point of the modeling? Should we care whether the model predicts an increased concentration on July 4th, 2003 compared to July 4th, 1977? We don't think so – not if real air quality has significantly improved.

Perhaps a weather analogy can underscore the point. If in 1990 there were 24 inches of precipitation in Bismarck – 2 inches per month; and if in 2000 there were 12 inches of precipitation in Bismarck – 1 inch per month — would we not say 2000 was much dryer than 1990? Of course we would. But if we applied an EPA-type approach, and if on June 15, 1990 there was no rain and on June 15, 2000 there was 1 inch of rain, we would conclude, anomalously, that 2000 was a wetter year.

The Clean Air Act was not intended to validate modeling that distorts the true state of air quality, or mislead us into believing air quality has gotten worse when in fact it has gotten better. The MAAL method gives us a far more realistic picture of real air quality changes than EPA's paired-in-time-and-space method, and is the right method to apply in this case.

V. MODEL INPUTS

A. Basin's Model Inputs Are the Same as EPA's in Most Cases, and Different Only in a Few

For the most part, in its Calpuff modeling Basin has used the same inputs as EPA Region 8. In some cases, it used EPA's inputs even though the State of North Dakota used different inputs. In those cases, Basin's intent is not to oppose the State's position, which may be meritorious. Rather, Basin's purpose is to try to minimize the points of difference with EPA.

For example: (1) Basin did not average modeled values spatially across all of the receptors in a Class I area as the State did; (2) in calculating baseline emissions for power plants, Basin did not use coal sulfur content data averaged over the life of the mine that supplied the plant on the baseline date (life-of-mine averaging), as the State did. Instead, it used sulfur content data only for baseline years, as EPA did; (3) Basin used 24-hour 90th percentile baseline and current emissions from power plants that have current CEM data, as EPA did, unlike the State, which used annual average baseline and current emission values to model 24-hour impacts; and (4) due to some uncertainty respecting the historical facts, Basin used EPA's more conservative baseline emission values for the Royal Oak briqueting plant, rather than the State's values.

Thus, most of the baseline and current emissions used by Basin are the same as or more conservative than those used by EPA. For example, current emissions modeled by Basin for all power plants are identical to the emissions modeled by EPA, and Basin's baseline emissions for Milton Young Unit 2, the Heskett power plant and the Beulah power plant are lower than EPA's.

There are only six significant differences between Basin's modeling and EPA's.[1]

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[1] There are other minor differences. These include: (1) EPA overstates current emissions from the Grasslands and Lignite Gas Plants because it has not yet taken into account that these facilities recently started to inject sour gas underground and thus have no emissions; (2) for some baseline sources, Basin calculated hourly emissions by dividing annual emissions by actual operating hours instead of dividing by total hours in the year (8760 hours) like EPA. EPA's method inaccurately assumes emissions are being discharged when they are not; (3) for Milton Young Unit 2, Basin followed the State's method of calculating baseline allowable emissions, using data from the 1979-80 baseline period – this was more conservative than EPA's calculation, based on permitted allowable emissions; (4) for the Beulah power plant, Basin could not discern how EPA derived its baseline emissions, and used the State's more conservative baseline values. It is the significant differences, however, not these minor differences, that account for the different outcomes modeled by Basin and EPA.

1. *Basin used superior meteorological input from the Rapid Update Cycle, Version 2 (RUC_2) prognostic mesoscale meteorological model, instead of EPA's outmoded and more limited conventional inputs.*

2. *For four emission units at three facilities, Basin used a baseline period other than 1976-77, because the different period was more representative of normal source operations, as determined by the State.*

3. *To calculate baseline emissions for those baseline power plants with current CEM data, Basin used site-specific sulfur emission factors instead of the standard AP-42 sulfur emission factor used by EPA. The State's and Basin's evidence shows that use of the standard sulfur emission factor skews the comparison between current and baseline emissions and therefore overestimates or underestimates incremental consumption.*

4. *For the Leland Olds Station, Basin calculated 90th percentile baseline values from more accurate site-specific daily data taken from company records.*

5. *Basin did not include in its modeling emissions from the Dakota Gasification Company's Great Plains Synfuels Plant or the Little Knife Gas Plant because these two sources were granted variances by the Federal Land Manager for the Class I Areas,*

despite past modeling that predicted increment exceedences. As a result of these variances, these sources should not be considered in determining compliance with Class I SO_2 increments.

6. ***Finally, Basin ran its model in two different ways: (a) it used the EPA's "paired in time and space" approach, and (b) it also used the State's so-called "MAAL" approach. Both ways of running the model show compliance with the Class I SO_2 increment. However, the MAAL approach typically shows less increment consumption. Basin submits that the MAAL approach is consistent with, and indeed is required by, the Clean Air Act.***

The reasons for using the MAAL approach are discussed in Section IV.B, *supra*. The other differences and the reasons for them are discussed in Sections IV.C and IV.E, *infra*. Before addressing these differences, however, we will address other model input objections raised by Region 8, which ENSR, Basin's modeling consultant, already has addressed.

B. Other Model Input Objections From Region 8, Already Addressed

In its modeling report released on May 23, 2003, at page 9, EPA states that it reviewed the modeling files prepared for Basin by ENSR, Basin's modeling consultant, found a number of serious flaws, and believes ENSR's model results are not credible. Some of these "flaws" may, indeed, have been incorporated in modeling performed by ENSR in the Spring of 2002. However, throughout the second half of 2002 and continuing into the first quarter of 2003, ENSR consulted extensively with the North Dakota Department of Health, which was the original source of many of these critiques,

and made appropriate corrections. In March 2003, ENSR released a revised and updated report, and supporting Attachments, in which it explained in detail all of the comments received from the State, and ENSR's corrections and responses. On or before April 18, 2003, a complete copy of ENSR's report and the Attachments were delivered to EPA Region 8.

Because of ENSR's extensive work with the NDDH between the Spring of 2002 and April 2003, none of the criticisms at page 9 of EPA's May 23, 2003 modeling report is valid. EPA has in its possession, and on May 23, 2003 had in its possession, documentation demonstrating that its criticisms had been addressed.

The following very briefly outlines why EPA's criticisms are not valid. Further details may be found in other materials, including: (1) ENSR's Revised Calpuff Analysis with Year 2000 MM5 Meteorological Data, PSD Increment Consumption in Class I Areas in North Dakota and Eastern Montana, March 2003, Document Number 3496-010-100; (2) ENSR's Addendum with Calpuff Results for 2001 and 2002 to ENSR's March 2003 Report, Document Number 3496-010-100a; and (3) Mr. Robert Paine's post-hearing written testimony submitted to the NDDH in connection with the Department's June 12-13 2003 hearing. Copies of all these documents are submitted herewith.

Criticism #1: Input data sets contained a number of serious technical errors, including a large lake (70 by 50 km) in the modeling domain where none exists; the failure to input appropriate cloud cover data; and an error in input coordinates for a number of sources in the northern part of the modeling domain.

Response #1: ENSR used a new land coding file provided by the NDDH that eliminated the "lake". ENSR used a surface file provided by the NDDH to address the missing cloud cover issue, and added data from five additional surface stations. ENSR used a new domain grid provided by the NDDH that restored Canadian sources to proper coordinates.

Criticism #2: ENSR's emission inventory failed to include the current year emissions of several sources.

Response #2: ENSR included these sources in its March and April 2003 modeling. ENSR's most recent modeling, presented on June 12-13, 2003 in North Dakota and in Mr. Paine's written testimony, does not include the Lignite Gas Plant because, as noted herein, sour gas from that plant is now injected, not flared, and there are no SO_2 emissions.

Criticism #3: Calmet technical options used by ENSR were not consistent with IWAQM recommendations for certain critical parameters, including the use of the O'Brien procedure, number of smoothing passes (NSMTH), etc.

Response #3: ENSR adopted the NDDH recommendations on these. The O'Brien procedure was not deployed. The number of smoothing passes was set to 4. Although ENSR and other experts believe including temperature sounding data from the GOES satellite in Step 2 is vastly superior to using only observations in Step 2, ENSR followed the NDDH recommendation to use only observations in Step 2.

Criticism #4: Only a single year (2000) of meteorological data was used, which is not consistent with EPA's guideline.

Response #4: In an April 2003 Addendum to its March 2003 report, ENSR modeled two additional years (2001, 2002) of RUC_2 prognostic mesoscale meteorological data, so we now have three years of meteorological data, consistent with EPA's Guideline on Air Quality Models, as revised April 15, 2003. Region 8 received the results of this modeling on May 2, 2003.

Criticism #5: MM_5 data was used to replace all of the actual measured surface and upper air weather observations. A comparison of wind speeds used in ENSR's modeling with actual observations showed the modeled wind speeds were higher than measured values, which likely resulted in lower predicted concentrations in Class I Areas.

Response #5: ENSR's current modeling does not replace all actual measured surface and upper air weather observations. EPA's assertion that ENSR's wind speeds were higher than measured values appears to have been borrowed from earlier assertions by the NDDH. Those assertions were not, in fact, supported by comparisons between modeled wind speeds and actual observations. ENSR has compared its modeled wind speeds with actual balloon sounding data *at the time of the soundings*, and confirmed that there is excellent agreement between the RUC_2 wind speeds used by ENSR and actual observations. *See* ENSR's March 2003 report and Mr. Paine's 2003 written testimony.

Elsewhere in its May 23, 2003 modeling report, EPA expressed concern about using meteorological data for years after 1994 because after that the National Weather Service installed automated surface stations, referred to as ASOS, to replace human observers. The ASOS stations do not measure cloud cover above 12,000 feet.

Preliminarily, it should be noted that if this concern were taken to heart, air quality modelers presumably would still be using pre-1994 data in the year 2094 and beyond – hardly a vote for progress, the National Weather Service, or new technology. Perhaps more importantly, ENSR performed sensitivity testing, comparing results with and without cloud cover data above 12,000 feet, and determined there was only a slight difference in the controlling modeled concentration – a little more than 1%. In fact, the modeling without the additional cloud cover data produced the slightly higher result. This demonstrates there is no need for EPA to be concerned about using post-1994 meteorological data. *See*, ENSR's Updated Modeling Results, June 2003 and Robert Paine's post-hearing 2003 written testimony, slide 66 and associated text.

C. Why RUC_2 Meteorological Data is Vastly Superior to EPA's Conventional Data

ENSR's modeling, as reported in its March 2003 report, used one year (2000) of RUC_2 prognostic mesoscale meteorological data. In April, 2003 ENSR published an Addendum with CALPUFF Results for 2001 and 2002 to ENSR's March 2003 Report, which used two additional years (2001 and 2002) of RUC_2 prognostic mesoscale meteorological data. This Addendum was distributed to Region 8 at a meeting on May 2, 2003, attended by the Regional Administrator and several members of the Region's air quality staff. Twenty-five compact disks with ENSR's modeling input and output files for this year 2000 modeling were delivered to Region 8 on or about April 25, 2003. On or about May 9, 2003, 50 additional compact disks with all of ENSR's modeling input and output files for 2001 and 2002, were delivered to Region 8.

1. Expert Meteorologist Witnesses Concur that RUC_2 is an Immensely Superior Meteorological Tool than EPA's Conventional Data.

Neither EPA nor the State has used meteorological inputs from the Rapid Update Cycle, Version 2 prognostic mesoscale meteorological model, at least not so far. EPA used meteorological data from 1990-94. For 1990, 1992 and 1994, EPA used supposedly enhanced MM_5 data. The sole sources of meteorological data used by EPA and the State are: (1) conventional hourly surface station data from 25 stations in North Dakota, South Dakota, Wyoming, Montana and Canada, only six or seven of which are located between the major North Dakota power plant sources and the Class I areas; and (2) twice-per-day balloon soundings, at 6:00 a.m. and 6:00 p.m., whereby instruments take a quick snapshot of conditions at various elevations as the balloon rises. Data was obtained for six balloon stations in North Dakota, South Dakota, Montana and Minnesota. Only one is in North Dakota, at the Bismarck Airport. From this meager database, the Calmet model, which is the meteorological component of Calpuff, is expected to predict what are the wind speeds, wind direction, and other meteorological parameters, at all places and all times within the modeling domain.

However, several expert witnesses, who testified at the NDDH hearing on June 12-13, 2003, uniformly agreed that the meager 1990-94 database furnished by the surface stations and twice-per-day balloon soundings, even when processed with MM_5, cannot tell us with any degree of reliability what the actual weather conditions were that carried emission plumes from North Dakota sources to the Class I areas. The meteorological data used by EPA and the State were characterized by these experts as "obsolete." They urged EPA to retire this dinosaur.[2]

[2] Basin does not contend that the superior RUC_2 meteorological data should be used routinely, for all modeling purposes. It is somewhat costly and modeling with this volume of data requires significant resources. For many applications that are more

Basin has provided to EPA and the State meteorological data that is far more extensive, accurate and predictive of real-world conditions. Basin's data is generated by the prognostic mesoscale meteorological model known as Rapid Update Cycle, Version 2, or RUC_2. RUC_2 is the model utilized by the National Weather Service (NWS) to forecast the weather. RUC_2 data is relied on by thousands of meteorological professionals to make critical decisions regarding tornadoes and severe thunderstorms, flash floods, hurricanes, wildfire forecasts and dispersion calculations essential to our homeland security. *See*, Post-hearing written testimony of Walter Lyons, at page (43). The RUC_2 model utilizes the conventional surface station and balloon data used by EPA, but it also utilizes thousands of additional data points, including hourly data from Next Generation Doppler Radar (NEXRAD) Stations, data gathered by planes landing and taking off (ACARS), and cloud drift data from satellites. RUC_2 is "initialized" each hour with data from all these sources. Based on this "initialized" data, it uses a sophisticated formula to predict the weather an hour later at all grid points within the modeled area. This hour-later prediction then is "nudged" to better conform to actual new data inputs for that hour. Attachment 6 to ENSR's March 2003 report provides an example of how the more frequent and more extensive RUC_2 data can identify important weather influences that are missed by EPA.

In North Dakota, conventional meteorological data includes virtually no measurements of upper air data between the major sources and Class I areas – virtually

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routine, less complex, do not involve long range transport or otherwise can provide acceptable answers with conventional meteorological data, there may be no need to use RUC_2. However, when conventional data isn't capable of doing the job, there is no justification for not using the far better RUC_2 meteorology.

no data in the area traversed by emission plumes. RUC_2 includes thousands of data points in time and space in the area traversed by emission plumes.

The experts uniformly agree that the RUC_2 data are vastly superior to the EPA's meteorological data. *See* 2002 testimony of Mr. Paine and the 2003 testimony of Messrs. Paine and Lyons submitted herewith. *See also*, the testimony of Messrs. Osborne and McVehil, presented at the June 12-13, 2003 hearing on behalf of Minnkota and Great River Energy, respectively. Note, for example, the following observations by Mr. Lyons: (1) "It is essential that these new meteorological resources [those used in RUC_2] be utilized by the air quality community in order for its modeling efforts to remain credible"; (2) "To continue 'business as usual' with respect to meteorological data inputs (as still permitted in current EPA modeling guidance) for regional modeling is simply not supportable in light of recent advances"; (3) "Use of RUC_2 provides access to a dense suite of observations which have been carefully quality assured and checked by large teams of professionals on a continuous basis. The RUC_2 prognostic model also allows the physics of the atmosphere to evolve during the hour between each FDDA [Four Dimensional Data Assimilation] step, proving all of the benefits of a prognostic model. FDDA, using both surface and upper air data at hourly intervals, should produce patently superior results to the approaches currently being promoted in EPA's modeling guidance." The testimony demonstrates in detail why the RUC_2 model is immensely more capable of accurately characterizing real-world weather than the limited conventional data. So why does EPA cling so tightly to outmoded and inaccurate data?

2. Region 8's Concerns with RUC_2 Are Not Well-Founded.

a. Richard Long's May 14, 2003 Letter

Mr. Richard Long of Region 8, in a letter to Mr. Terry O'Clair of the NDDH dated May 14, 2003, observed that "[c]onceptually, this technique [RUC_2] may offer the ability to supplement the existing data set used in air pollution modeling." Mr. Long then noted, however, that EPA is not currently using this type of data for regulatory modeling because this is new technology and the modeling community has not yet addressed a number of "fundamental regulatory issues." The following are Basin's responses to Mr. Long's list of concerns.

Concern #1: The quality and accuracy of the Rapid Update Cycle Version 2 (RUC_2) data compared to data from conventional sources.

Response #1: There is no credible evidence offered by EPA to support this concern. RUC_2 is used throughout the United States, day in and day out, by the National Weather Services (NWS) to predict weather conditions. As noted in Section V.C.1., *supra*, Mr. Lyons testified that RUC_2 observations are quality assured by large teams of professionals on a continuous basis. Over the course of a decade, the NWS invested $5 billion in the national weather data infrastructure to create the capability and technology to gather the extensive data needed to run RUC_2 and enhance the quality of weather forecasting. *See*, post-hearing 2003 written testimony of Walter Lyons, at pg. 12. Four expert meteorologists testified at the June 12-13, 2003 hearing that RUC_2 was unequivocally superior to the outmoded data used by EPA for regulatory modeling, and that the consensus among meteorologists, excepting only EPA, is that RUC_2 as vastly superior. This testimony is unrebutted.

Concern #2: The quantity and representativeness of data that this technique actually provides for modeling input (much of the aircraft and NEXRAD wind information are not continuously available).

Response #2: We're not sure we understand the nature of this concern. If it means that airplanes are not continuously landing or taking off in the modeling domain, and NEXRAD data is fed into RUC_2 hourly, rather than continuously, that is true. Compared to the meager spatial and temporal coverage provided by EPA's conventional data base, however, RUC_2 has vastly better coverage, a far greater quantity of data, and superior spatial representativeness. Only RUC_2 provides significant upper air data in the area between the major North Dakota sources and Class I areas traversed by emission plumes. There is no credible evidence to the contrary.

Concern #3: The compatibility of using spatially averaged RUC data in modeling systems that were developed to use data from conventional sources.

Response #3: If Region 8 is claiming that RUC_2 is incompatible with Calpuff, there is no basis for such a claim. The unrebutted testimony of the experts at the June 12-13, 2003 hearing was that RUC_2 is fully compatible with Calpuff. Moreover, EPA's own Guideline on Air Quality Models belies Mr. Long's concern. According to the Guideline:

(i) "*For long range transport modeling assessments* [such as Calpuff] . . . *use of output from prognostic mesoscale meteorological models is encouraged.*" (Emphasis added). Guideline, Section 9.3.C

RUC_2 is a prognostic mesoscale meteorological model, one of the best, latest and most appropriate for this application. Post-hearing 2003 written testimony of Walter Lyons.

(ii) "Acceptance for use of output from prognostic mesoscale meteorological models is contingent on concurrence by the appropriate reviewing authorities . . . that the data are of acceptable quality, which can be demonstrated through statistical comparisons with observations of winds aloft and at the surface at several appropriate locations." Id.

ENSR has performed statistical comparisons between RUC_2 data and balloon data, and found excellent agreement. *See*, ENSR March 2003 Report, Section 3.0 and post-hearing 2003 written testimony of Robert Paine, slides 24-27 and accompanying text. ENSR also has compared RUC_2 data with wind measurements from several wind towers in North Dakota, and with data from the EPA/NDDH modeling, and determined that RUC_2 provides far better agreement with the wind tower data than the EPA/NDDH data. *See*, Comparison of CALMET Wind Speed Predictions with Measurements from Wind Energy Meteorological Towers in Western North Dakota, April 2003. Although the reviewing authority (NDDH) has not yet concurred that ENSR's RUC_2 data are acceptable, Basin is hopeful that the Department will be persuaded by the testimony at the June 12-13, 2003 hearing. Even if the Department did not concur, regulatory agencies may not refuse to authorize the use of demonstrably superior information. *See* Section V.D., *infra*.

(iii) "For LRT situations, and for complex wind situations, if only NWS or comparable standard meteorological observations are employed, five years of

meteorological data . . . should be used . . . *Less than five, but at least three, years of meteorological data (need not be consecutive) may be used if mesoscale meteorological fields are available.*" (Emphasis added). Guideline, Section 9.3.1.2.d

b. Region 8's Sensitivity Testing

In addition to expressing the above concerns, Mr. Long notes that EPA and the USF&WS performed sensitivity tests, comparing the differences in modeling results with and without RUC_2 data, and concluded there was no significant difference between the results and therefore the use of RUC_2 makes no difference. ENSR reviewed this sensitivity testing and learned that it used an "R2" value of 125 kilometers, which effectively wiped out all of the RUC_2 data within that radius. So, of course, there was no difference in EPA's skewed "comparison." When a subsequent comparison was made by Mr. Allen of the USF&WS, using appropriate values for R2, he found the non-RUC_2 run produced a second-highest 24-hour concentration that was 60% higher than the RUC_2 run. *See*, post-hearing 2003 written testimony of Robert Paine, slides 64 and 65 and associated text. When properly and fairly evaluated, RUC_2 makes a very big difference.

c. Alpine Geophysics

At pages 5 and 6 of its May 2003 report, Region 8 notes it retained a contractor to do MM_5 modeling with 1994 meteorological data, and evaluate the performance of those MM_5 predictions. The contractor, Alpine Geophysics, compared the performance of its modeling with historical MM_5 applications that have been accepted for use in regulatory applications elsewhere, and concluded its modeling performed with approximately the same skill level as the previous applications. The Alpine Geophysics report is on Region 8's web site.

The Alpine Geophysics report begs the question whether EPA's meteorological data is inferior to the RUC_2 data used by Basin. Alpine Geophysics' data were "obtained from the conventional National Weather Service (NWS) twice-daily radiosondes [balloons] and three-hour NWS surface observations." Alpine Geophysics report, page 2-2. Modeling results with this conventional data were then compared to other modeling results using MM_5 inputs based on conventional data and, not surprisingly, there was reasonably good agreement.

Nothing in the Alpine Geophysics report attempts or purports to compare the merits, accuracy or reliability of the inputs used by Alpine Geophysics with RUC_2-based inputs.

While MM_5 is a prognostic mesoscale meteorological model, and generally is believed to enhance the accuracy of dispersion model inputs compared to simply feeding raw NWS data into Calmet (the Calpuff model meteorological pre-processor) it cannot make a silk purse out of the proverbial sow's ear. Alpine Geophysics used the MM_5 model to process conventional NWS data. Because the data input to MM_5 was so far inferior to the richer and far more extensive database used in the RUC_2 prognostic mesoscale meteorological model, the MM_5 results with conventional data inputs could not possibly achieve the level of accuracy of RUC_2. Moreover, as noted by Walter Lyons, "MM_5 is reaching the end of its useful lifecycle, and will soon be phased out by a new model called the WRF (Weather Research and Forecasting) model." Post-hearing 2003 written testimony of Walter Lyons. The Alpine Geophysical report, therefore, is, at best, irrelevant and, at worst, misleading when applied to these circumstances.

d. Confidentiality Concerns

Mr. Long's May 14, 2003 letter says the RUC_2 data used by ENSR in this case cannot be used for regulatory purposes because of limitations on its dissemination contained in the license agreement pursuant to which it was obtained by Basin. Mr. Long contends that "under EPA regulations models/data must be in the public domain." After obtaining Mr. Long's letter, Basin Electric entered into a revised license agreement and advised EPA that the RUC_2 data supplied to EPA could be distributed to any interested party, with virtually no limit, for purposes related to the determination whether Class I SO_2 increments were being exceeded in North Dakota and eastern Montana. *See* letter dated June 5, 2003 from Lawrence E. Volmert of Holland & Hart to Sara Laumann of Region 8. We believe this resolves Mr. Long's concern about confidential information. We have received no contrary indication from Region 8.

The only possible support for Mr. Long's contention we can find is the statement at 40 C.F.R. Part 51, App. W, Section 3.1.1.c.vi that

> "The developer must be willing to make the model available to users at reasonable cost or make it available for public access through the Internet or National Technical Information Service: the model cannot be proprietary."

This provision does not, however, support Mr. Long's contention because: (1) this language only refers to air quality dispersion models, which are the subject of Appendix W. It does not apply to meteorological data or meteorological models; and (2) Basin now has made the RUC_2 data available to EPA and anyone else for purposes related to the issue whether Class I SO_2 increments are violated.

Moreover, EPA itself, in the recent NO_x SIP call proceedings, utilized a proprietary model over objections of commenters. Specifically, it used the UAM-V

model, as well as the Systems Application International Mesoscale Model (SAIMM). Commenters objected they had to purchase licenses to use these models, or hire the model owner as a contractor. EPA stated that because the UAM-V model, in general, had been privately developed, EPA believed that reasonable fees for its use should be expected. EPA further stated it was not aware of any case where someone who requested access to the model for the purpose of the NO_x SIP call was denied access. *See* 63 Fed. Reg. 57356 (Oct. 27, 1998); *see also*, Responses to Significant Comments on the Proposed Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group (OTAG) Region for Purposes of Reducing Regional Transport of Ozone (62 FR 60318, November 7, 1997 and 63 FR 25902, May 11, 1998) *available at* http://www.epa.gov/ttncaaa1/otag/final.wpd. That case parallels this one. Both instances involve a model/data generally requiring a license, but in neither case is an interested party denied access for purposes of the pending proceeding. Licensable models were allowed to be used for the NO_x SIP call, and RUC_2 may legitimately be used in this case.

3. Additional Reasons Why RUC_2 is Superior.

Further contributing to the overwhelming superiority of RUC_2 are two additional studies: (1) ENSR's model performance evaluation, and (2) ENSR's wind tower study.

a. Performance Evaluation

In section 30 of its June, 2003 modeling report, submitted herewith, ENSR compared the performance of Calpuff modeling using RUC_2 data with Calpuff modeling with conventional meteorology. Both model runs were compared with monitored values at the TRNP South Unit and the Dunn Center monitoring sites, unpaired in time. This

evaluation showed that modeling using RUC_2 was more accurate and less biased than the non-RUC_2 modeling.

One of the ongoing disagreements in this case has been a dispute over what is the most appropriate background ambient level of SO_2 to use in making this type of comparison. In his letter of May 14, 2003 to Mr. O'Clair of the NDDH, Mr. Long of Region 8 criticized the model evaluation done by ENSR in the March, 2003 report because it had used a background concentration of 2 micrograms/cubic meter. Mr. Long indicated EPA assumes a negligible background because all major sources within 250 km were already modeled and EPA does not believe contributions from peat bogs or local vehicle traffic are significant.

EPA Guidelines on Air Quality Models, Section 9.2.1.1, provides that "[b]ackground concentrations are an essential part of the total air quality concentration to be considered in determining source impacts." ENSR's June, 2003 report cites several studies of background SO_2 concentrations in the United States and elsewhere. The background found in these studies ranged from 0.5 micrograms/cubic meter, to 2.6 micrograms/cubic meter, to a statement that SO_2 emissions from land-based biological decay (including peat bogs) are approximately the same as man-made emissions. It is of course, difficult to estimate background with certainty because monitoring equipment in general use cannot detect levels below 2.6 micrograms/cubic meter.

ENSR therefore used a range of backgrounds for its June 2003 evaluation, from 0.5 micrograms to 2.0 micrograms. This covers the range assumed in the cited studies. For each assumed background level, ENSR found its RUC_2-based modeling to have a low bias It also found for each background level, significantly better agreement

between ENSR's RUC_2-based modeling and observed values, than between non-RUC_2-based modeling and observed values.

In his letter of June 27, 2003 to Mr. David Glatt, Hearing Officer, submitted herewith, Mr. Robert Connery pointed out that in the baseline years, there was a very high volume of SO_2 emissions from upwind Montana sources that are more than 250 km from the Class I areas and therefore are not modeled. Mr. Connery suggests that emissions from these sources are so high they may well have added to "background" concentrations.

Use of 90^{th} percentile values for increment consumption modeling adds significant conservatism compared to real conditions, and further ensures that RUC_2-based model results do not underpredict actual increment consumption.

b. Wind Tower Studies

As noted in Section V.C.2.a., *supra*, RUC_2 wind speed data shows excellent agreement with observed wind speeds at the Bismarck balloon sounding location. To further evaluate the accuracy of RUC_2 information, ENSR compared RUC_2 predictions with more extensive measured wind speed data at several wind tower locations.

In the 1990s the Electric Power Research Institute installed many wind towers in North Dakota to assess the potential for wind-generated electrical power. ENSR studied wind speeds at six of these wind tower sites in North Dakota, located in the area of plume transport between major sources and the Class I areas. ENSR divided up the calendar day into eight three-hour periods, and for each three-hour period compared annual average wind speeds at each location based on three sources: (1) actual measured wind speeds at the tower; (2) wind speeds predicted by RUC_2, and (3) wind speeds predicted using conventional meteorology. ENSR found that both the RUC_2 and

conventional data underpredicted actual wind speeds, but the RUC_2 predictions were substantially more accurate than conventional data.

The study also demonstrated the well-known phenomenon known as the nocturnal low-level jet, which refers to the frequent occurrence of substantially higher nighttime wind speeds at elevated heights (e.g., 55 meters) than at the surface. Conventional meteorological information does not incorporate this data, and therefore substantially understates actual upper air wind speeds.

ENSR did a further evaluation to determine whether it is fair to compare the measured wind speeds from the wind towers with modeled wind speeds, which may not predict conditions at the exact location of the tower, but instead may predict nearby wind speeds. ENSR used a software program called Windfarm to make this evaluation, and found that at four of five sites evaluated, the tower wind speeds were about 5% higher than in the surrounding area and at one site the tower speeds were about 9% higher. These differences do not alter the conclusions of the wind tower study, that both RUC_2 and conventional data underpredict actual wind speeds, and that RUC_2 is substantially more accurate than the conventional data. *See* post-hearing 2003 testimony of Robert Paine.

4. Conclusion.

The case for the use of RUC_2 is compelling. EPA's own Guideline on Air Quality Models encourages the use of prognostic mesoscale meteorological models such as RUC_2. The NWS spent billions on RUC_2 to improve its weather forecasting. RUC_2 shows far better agreement with measured values, including values at wind tower sites, than conventional meteorology. The only thing that stands in the way of using this

superior information is Region 8's apparent resistance to change. It's time Region 8 parked the old Studebaker and got behind the wheel of the Lexus.

D. Region 8 May Not Reject Superior Model Inputs in Favor of Inferior Data

As noted in Section V.C., *supra*, EPA's *Guideline on Air Quality Models* encourages the use of prognostic mesoscale meteorological models such as RUC_2 for modeling long-range transport, and endorses the use of three years of data from such models as sufficient. There is compelling evidence that RUC_2 is immensely more capable, far more accurate, and thoroughly superior to the conventional meteorological data that has been used by Region 8. These should be adequate reasons for Region 8 to reconsider the modeling it has done and use RUC_2 data to model Class I SO_2 increment consumption.

There is, however, an additional reason — under the circumstances, the law does not permit Region 8 to reject the use of the superior RUC_2 data, or other superior data, in favor of less reliable, less accurate, inferior data.

Although courts in many cases review EPA modeling deferentially, they do inquire into the reasonableness of agency action and will overturn such action if it is arbitrary or capricious, or not in accordance with law. *See, e.g., Michigan v. U.S. EPA*, 213 F.3d 663, 681-82.

This means the agency "must examine the relevant data and articulate a satisfactory explanation for its action including a 'rational connection between the facts found and the choice made.'" *Motor Vehicle Manuf. Assoc. v. State Farm*, 463 U.S. 29, 43 (1983), *citing Burlington Truck Lines v. U.S.*, 371 U.S. 156, 168 (1962). Agency action may be overturned if it "runs counter to the evidence before the agency, or is so

implausible that it could not be ascribed to a difference in view or the product of agency expertise." *Id.* The court in *Motor Vehicle Manuf. Assoc.* quoted the following with approval from *Burlington Truck Lines v. U.S.*:

> Expert discretion is the lifeblood of the administrative process, but *unless we make the requirements for administrative action strict and demanding, expertise, the strength of modern government, can become a monster which rules with no practical limits on its discretion.* (emphasis added) (citation omitted).

371 U.S., at 167.

In *Brower v. Evans*, 257 F.3d 1058 (9th Cir. 2001), which arose under the Endangered Species Act, the court observed that

> [t]he deference accorded an agency's scientific or technical expertise is not unlimited (citation omitted). The presumption of agency expertise can be rebutted when its decisions, while relying on scientific expertise, are not reasoned (at 1067).

And in *Appalachian Power Co. v. E.P.A.*, 249 F.3d 1032 (D.C. Cir. 2001), the court, although applying a highly deferential standard of review to EPA's use of a particular model, ruled against the agency where its action ran counter to the best information available. The court said:

> While courts routinely defer to agency modelings of complex phenomena, *model assumptions must have a 'rational relationship' to the real world* (emphasis added) (citation omitted)

249 F.3d at 1053.

* * *

> The EPA is well aware of its obligation to 'examine the relevant data and articulate a satisfactory explanation for its action,' yet it failed to discharge this obligation here. (citation omitted)

249 F.3d at 1054.

* * *

> The EPA has 'undoubted power to use predictive models' but *only so long as it 'explain[s] the assumptions and methodology used in preparing the model' and 'provide[s] a complete analytic defense' should the model be challenged* (emphasis added) (citation omitted)

Id.

In its modeling, EPA had used certain projected growth rates to estimate facility utilization growth for 1996-2007. However, these growth rates were demonstrably inconsistent with known facts, including the fact that actual growth in 1998 already exceeded the growth projected by EPA for 2007. Noting that EPA had not "addressed what appear to be stark disparities between its projections and real world observations," the court remanded the matter to the agency for corrective action. 249 F.3d 1032.

In *Cincinnati Gas & Electric Co. v. E.P.A.*, 578 F.2d 660 (6th Cir. 1978), EPA sought to apply a particular meteorological assumption (the "Class A assumption"). Petitioner presented three studies to undermine the Class A assumption and urged the use of a Class B assumption. EPA declined to adopt the Class B alternative until further studies could be done to substantiate petitioners' theories. The court, however, remanded the matter to EPA, noting the agency could not ignore the contrary conclusions of experts, including experts convened at EPA's request.

Michigan v. U.S. EPA, 213 F.3d 663 (D.C. Cir. 2000) is another modeling case, in which EPA sought to include Wisconsin in a SIP call, asserting that because the state contributed to ozone over Lake Michigan, it therefore contributed to ozone in other states. The court ruled against EPA because the evidence did not show contribution to nonattainment in another state, and said

> EPA must "demonstrate[] a reasonable connection between the facts found on the record and its decision" made pursuant to its statutory authority. (citation omitted)

213 F.3d at 681.

Thus, even assuming it is EPA, not the NDDH, which has authority and responsibility for all decisions affecting the modeling of Class I increment consumption, including the selection of meteorology, and assuming further that EPA's newly updated *Guideline on Air Quality Models* did not encourage the use of prognostic mesoscale meteorological models such as RUC_2, Region 8 would not have the discretion to ignore or reject overwhelming evidence that RUC_2 provides more and better data, and is proven to agree far better with actual meteorological observations than the conventional data used by EPA. To reject the better data would run counter to the evidence, and thus be error on the part of Region 8.

EPA also does not have the discretion to ignore or reject demonstrably better and more reliable baseline emission data, presented in Sections V.E.3 and V.E.4, *infra*.

E. Emission Inventory Issues

As noted above, Basin chose to use the same emission inventory as EPA, with four significant exceptions. The emissions modeled by ENSR, Basin's consultant, are those listed in the table attached to the Declaration of Robert Hammer, submitted herewith. A copy of the same table is included in the PowerPoint slides of Lawrence Volmert for the NDDH hearing of June 12-13, 2003, also submitted herewith. The reasons for each of the four exceptions are provided below.

1. Baseline Years

The minor source baseline date in this area of North Dakota is December 19, 1977. The two-year period immediately preceding this date in 1976-77. EPA contends

that deviations from the 1976-77 baseline period are not allowed "unless data from alternative years provides a better estimate of emissions that actually occurred in the 1976-77 time period." This is inherently contradictory. Data from other years cannot, by definition, provide a better estimate of 1976-77 emissions than actual 1976-77 data.

EPA goes on to say the only exception would be if some catastrophic event occurred in 1976-77 such as a strike, a major industrial accident or retooling. EPA's assertion ignores the straightforward language of the agency's own regulations. The analysis of those regulations begins with the definition of ambient air increments, which is defined as the maximum allowable increase over the "baseline concentration." 40 C.F.R. § 51.166(c). "Baseline concentration" in turn is defined as the ambient concentration existing at the time of the minor source baseline date, and includes the "actual emissions" representative of sources in existence on that date. 40 C.F.R. § 51.166(b)(13). "Actual emissions" in turn is defined, in general, as "the average rate, in tons per year, at which the unit actually emitted the pollutant *during a two-year period which precedes the [minor source baseline date]* and which is representative of normal operations." 40 C.F.R. § 51.166(b)(21). This is what EPA relies on in selecting 1976-77 emissions as the baseline emissions in this case.

However, the regulation does not stop there, but rather continues: "*The reviewing authority may allow the use of a different time period upon a determination that it is more representative of normal source operation.*"(Emphasis added.) 40 C.F.R. § 51.166(b)(21)(ii). Nowhere does the regulation say that a more representative time period may be used only if a catastrophe occurred at a particular emitting unit in the two-year period preceding the minor source baseline date. EPA cites a couple of

internal guidance documents as purported authority for its contention, but the agency cannot amend a duly promulgated regulation by means of informal guidance. *See, e.g., Appalachian Power Co. v. EPA*, 208 F.3d 1015, 1028 (D.C. Cir. 2000). Moreover, EPA's informal guidance contradicts its own interpretation of the regulations, announced when the regulations were adopted. EPA, in the preamble to its 1980 adoption of the current rule, stated:

> If a source can demonstrate that its *operation after the baseline date* is *more representative* of *normal source operation* than its operation preceding the baseline, the definition of actual emissions *allows* the *reviewing authority to use the more representative period* to calculate the source's actual emissions contribution to the baseline concentration. EPA thus believes that *sufficient flexibility exists* within the definition of actual emissions *to allow any reasonably anticipated increases or decreases reflecting normal source operation to be included in the baseline concentration*. (Emphasis added.)

45 Fed. Reg. 52714-15 (Aug. 7, 1980).

In this case, the reviewing authority, the NDDH, determined that for four units at three power plants – Leland Olds Unit 2, Milton Young Units 1 and 2, and Stanton Unit 1 – a different two-year period was more representative of normal operations than 1976-77. Generally, the Department selected the consecutive two-year period between 1975 and 1980 with the highest average hourly heat input, and also noted unusual circumstances at several of the units during 1976-77. *See* the NDDH report, Prevention of Significant Deterioration, Sulfur Dioxide, Final Baseline Emission Rates, May 2003.

Milton Young Unit 2 was in a startup mode in 1977, and operated only eight months during 1976-77. Even Region 8 made a special case for this Unit and used

allowable emissions as baseline emissions because 1976-77 was not representative of normal operation.

At Stanton Unit 1, the Department found the plant experienced difficulty in supplying enough steam to the turbine during 1975-77 because high sodium coal was causing fouling of the boiler at that time. Therefore, the Department determined 1977-78 was more representative of normal operation.

At Leland Olds, the Department found that in 1976 Unit 2 was in a startup mode and experienced problems with extended outages. Therefore, 1977-78 was determined to be more representative of normal operations. Mr. Curt Melland, plant manager for Leland Olds, testified in extensive detail regarding the fact that Unit 2 was one of the first boilers of its kind and size installed in the U.S., and it took Basin a long time to learn how to operate it to avoid outages. Mr. Melland went through a long litany of Unit 2 outages in 1976, to explain why 1977-78 was more representative of normal source operation than 1976-77.

Not only does EPA's rigid clinging to 1976-77 ignore the language of the regulations and the agency's concurrent interpretation, it also contradicts the underlying policy applied when EPA adopted the so-called "WEPCO rule." As a result of *Wisconsin Electric Power Co. v. Reilly*, (WEPCO), 893 F.2d 901 (7th Cir. 1990), in 1992 EPA modified its rules for determining baseline emissions for electric power plants. The new rule created a presumption that "*any two consecutive years within the five years prior to the proposed change is representative of normal operations.*" (Emphasis added.) 57 Fed. Reg. 32314, 32323 (July 21, 1992).

The rule does not apply directly to the increment consumption issues here, but rather to PSD applicability. Nonetheless, EPA's announced rationale for allowing flexibility in selecting baseline years does apply here. EPA determined that using two consecutive years out of five "better takes into consideration that *electricity demand and resultant utility operations fluctuate in response to various factors* such as annual variability in climate or economic condition, *that affect demand.* By expanding a baseline for a utility to any two in the last five years, *these types of fluctuations in operations can be more realistically considered.*" (Emphasis added.) *Id.* at 32325.

In a recent case involving power plants, EPA's Environmental Appeals Board ("EAB") endorsed the selection of alternative and more representative years without requiring a showing of catastrophic circumstances. In *In re: Tennessee Valley Authority* ("TVA"), 2000 EPA App Lexis 25 * 164-173 (2000), the EAB accepted TVA's approach of using a baseline 24-month period with the highest annual emission rate during the five years preceding the project at issue, because it took into account fluctuations in utilization of the unit due to weather, availability of other units on the system, etc. There was debate between the parties whether TVA was entitled to the benefit of the WEPCO rule, which expressly allows power plants to choose any 2 of the previous 5 years in a permitting context. However, the Board found it unnecessary to decide whether WEPCO applied because *TVA's evidence was sufficient to demonstrate a period other than the 2 years preceding the project was more representative of normal operations, even without the benefit of the WEPCO rule.* The NDDH's assessment of more representative years parallels the approach approved in the *TVA* case, but is even more compelling because it takes into account additional site-specific

factors. Especially for Basin's Leland Olds Station, Mr. Melland's testimony goes substantially beyond what was accepted as sufficient by the EAB.

Arrayed against the informal guidance cited by Region 8 is the unequivocal language of the regulations, the concurrent interpretation set forth in the August 7, 1980 Federal Register Preamble, and the agency's own acknowledgement in the WEPCO rule and the *TVA* case that fluctuations in the electric power industry justify flexibility in determining representative operations. We urge Region 8 to bow to the overwhelming weight of authority and accept the State's alternative baseline periods for the 4 units.

2. Variance Sources

EPA's modeling included two sources, the Great Plains Synfuel Plant and the Little Knife Gas Plant, which had been granted variances by the Federal Land Manager, and thus were permitted despite modeling showing they would contribute to violations of the Class I increment (although they did not contribute to exceedances of the alternative increments applicable to variance sources, discussed *infra*.) The FLM concluded that neither of these sources would adversely impact Air Quality Related Values. EPA has erroneously included the emissions from these sources in its modeling.

The most recent of the variances was published on March 12, 1993, for the Great Plains Synfuels Plant, although modeling predicted violations of the three-hour and 24-hour SO_2 Class I increments at the TRNP and the 24-hour increment at the Lost Wood Wilderness Area. The Department of the Interior found that the project would not increase perceptible plume impacts or contribute to regional haze; that there was no evidence of existing adverse impacts on biological resources due to air pollution; that air quality in North Dakota had improved since 1984; that the maximum predicted

concentrations of SO_2 were well below the alternate Class I increments for variance sources; and that the project would not cause or contribute to impairment of ecosystems or the quality of visitor experience, or result in a diminution of the national significance of the Class I Areas. 58 Fed. Reg. 13639 (March 12, 1993). Similar findings previously had been made respecting the Little Knife Gas Plant and other sources permitted concurrently with it. 47 Fed. Reg. 41480 (Sept. 20, 1982).

Despite the granting of these variances, EPA Region 8 included the variance sources in its modeling, thereby effectively revoking the variances granted by the FLMs. There is no authority for doing so, and EPA's action conflicts with the letter and spirit of the variance regulations. The Class I increments were adopted as a means to an end, to protect AQRVs. It is the AQRVs, not the Class I increments, which are the ultimate determinant regarding air quality in Class I Areas. Class I increments were described by Congress as "a flexible test . . . for determining where the burden of proof lies and is an index of changes in air quality. It is not the final determinant for approval or disapproval of the permit application." S. Rep. 95-127, 95th Cong. 1st Sess., at 35 (May 10, 1977). Congress clearly stated that the Class I increments and AQRVs are intended "to provide additional protection for air quality in areas where the Federal Government has a special stewardship to protect the *natural values of a national resource*" (emphasis added). *Id.* at 34.

EPA's regulations confirm that it is AQRVs, and not the Class I increments, which are the final determinant for protecting air quality in Class I Areas. Permits can be denied based on AQRVs even when Class I increments are met. Conversely, permits can be granted where there is no adverse impact on AQRVs, despite modeled

predictions of Class I increment violations. In North Dakota, the FLMs have determined on at least three occasions that AQRVs are protected at levels of SO_2 significantly exceeding current levels. For EPA now to include the variance sources in its modeling is to elevate the means (increments) above the end (AQRVs) and distort the intent of the regulatory scheme.

EPA's current position conflicts with two decades of consistent practice to the contrary. Until now, EPA has never suggested that the modeled increment violations which led to the granting of variances in 1982, 1984 and 1993 must be remedied by means of SIP revisions. EPA has offered no sound reason for reversing two decades of precedent.

Where a variance is granted, the Class I increment no longer applies. Instead, an alternate increment applies to the variance source. 40 CFR § 51.166(p)(4). By including two variance sources in its Class I increment modeling, EPA effectively would make made these sources again subject to the Class I increment, in contravention of the variances granted to the sources and the alternate increments which are applicable under 40 CFR § 51.166(p)(4).

EPA's position effectively would nullify any and all variances granted pursuant to the PSD regulations. There is no authority for doing so. In many cases, it could effectively preclude resort to the variance provisions at all. For example, if a well-controlled proposed source were the only source impacting a Class I Area, was modeled as exceeding a Class I increment but otherwise would qualify for a variance, it could not obtain a variance because by definition, it could not meet the increment. In such a case, EPA's position is exposed as the inherently contradictory stand that it is.

3. *Alternative Sulfur Emission Factors*

Mr. Robert Hammer of Tetra Tech EMI testified in 2002 and again in 2003 that the use of a different method to quantify current emissions than the method used to quantify baseline emissions was resulting in a skewed determination of increment consumption. Continuous emission monitors are used to measure current emissions, while calculations based on an AP-42 equation are used to calculate baseline emissions. The difference in methodology inherently introduces the potential for error.

For example, one way of measuring the speed of an automobile is to follow it, attempting to maintain a constant distance behind, while observing one's own speedometer. Another method is to use a radar gun. There is no assurance that the speed of an automobile as measured with one method will be the same as the speed of the same automobile as measured with the other method.

For Basin's Leland Olds Station, Mr. Hammer compared emissions for each year from 1996-2002 based on CEM data, with emissions for the same period using the AP-42 equation, and found the AP-42 values were substantially less than the CEM values. This discrepancy results in an overestimate of increment consumption.

The default AP-42 equation includes a sulfur emission factor of 30. To correct for the bias demonstrated by Mr. Hammer, the NDDH, using site-specific data, calculated a revised sulfur emission factor for each baseline emission unit for which current CEM data is available. In the majority of cases, the revised factor was greater than 30; but in at least one case it was less than 30, indicating the standard emission factor was overestimating baseline emissions.

Mr. Hammer demonstrated, using Basin's Leland Olds Station as an example, the use of the NDDH's revised emission factor greatly reduces the bias associated with the use of the default AP-42 emission factor.

It should be noted that Basin does not quarrel with the use of CEM data to calculate current emissions. Nor does it contend that the use of a revised emission factor is supported by high or low values for the percent sodium in coal, an option which is provided within AP-42 itself. We contend, rather, that it is not appropriate to use values calculated with an equation of limited reliability for purposes of comparison to CEM values.

As testified on June 12, 2003 by Mr. Bachman of the NDDH, the introduction to AP-42 cautions that

> "Use of these factors as source-specific limits and/or emission regulation compliance determination is not recommended by EPA.

AP-42, Introduction, at p. 2.

* * *

> "Data from source-specific emissions tests or continuous emission monitors are usually preferred for estimating a source's emissions because those data provide the best representation of the tested source's emissions.

AP-42, Introduction, at p. 1.

* * *

> "Average emissions differ significantly from source to source and, therefore, emission factors frequently may not provide adequate estimates of the average emissions for a specific source. The extent of between-source availability that exists, even among similar sources, can be large depending on process, control system and pollutant.

AP-42, Introduction, at p. 3.

* * *

> "Using emission factors to estimate short-term emissions will add further uncertainties to the emissions estimate. Short term emissions from a single source often vary significantly with time . . . because of fluctuations in process operating conditions, control device operating conditions, raw materials, ambient conditions, and other factors.

AP-42, Introduction, at p. 4.

* * *

> "To assess with-in source variability and the range of short term emissions from a source, one needs either a number of test performed over an extended period of time or continuous monitoring data from an individual source."

AP-42, Introduction, at p. 5.

Recognizing the inherent limitations of AP-42, the NDDH developed a way to calculate baseline emissions that is substantially more accurate when applied to a specific source, and provides a far better comparison with CEM data than could be achieved using the default AP-42 equation. It would be indefensible to use a less accurate method when a demonstrably more accurate method exists, as shown in Section V.D., *supra*.

4. Leland Olds Site-specific Baseline Emissions

The site-specific sulfur emission factors developed by the NDDH are a more reliable and accurate basis for calculating baseline emissions for individual sources than the default AP-42 factor used by Region 8. The Department's calculations, nonetheless rely on limited annual average coal sulfur content information, submitted in Annual Emission Inventory Reports filed by sources, to calculate average emissions. In order to convert average emissions to 90th percentile baseline emissions, Region 8 uses a peak-to-mean emissions ratio derived from current CEM data gathered 25 years after the baseline date. During that 25 years, source operating and practices, fuel

characteristics and other factors could have changed, posing an issue of the reliability of EPA's peak-to-mean ratios. In most cases, there may be no alternative to using the Department's average sulfur data and EPA's peak-to-mean ratio. For Basin's Leland Olds Station; however, Mr. Curt Melland, plant manager, retrieved company records for the baseline years and used it to calculate more accurate daily emissions for LOS units 1 and 2. On June 12-13, 2003, Mr. Melland testified how he did that.

Two to four times per month during the baseline periods for Units 1 and 2, a coal sample was analyzed for sulfur content. Mr. Melland used this information, with company records of daily coal BTU content, coal burned monthly, and daily and monthly power generated, to calculate daily SO_2 emissions for each day for which sulfur content test result was obtained.

For the baseline period for each LOS unit, Mr. Melland was able to calculate 60-90 daily emission rates. Using the 90^{th} percentile method used by Region 8 to select current emission rates, he then rank-ordered these daily rates for each unit, identified the highest 10% of daily values, and selected the next in order as the 90^{th} percentile baseline value.

This provides us with more accurate baseline emissions for Leland Olds than we have for other baseline sources. Although we don't have information as accurate as this for other sources, we ought to use the more accurate information we do have for Leland Olds. To use inferior data when superior data is available would not be reasonable or legally defensible, as shown in Section V.D., *supra*.

VI. THE STATE OF NORTH DAKOTA HAS THE PRIMARY RESPONSIBILITY AND AUTHORITY TO DETERMINE WHETHER ITS SIP IS PROTECTING CLASS I INCREMENTS, AND ITS DECISION SHOULD BE ACCEPTED UNLESS CLEARLY ERRONEOUS

For the reasons noted above, and based on compelling evidence, it would be erroneous for Region 8 to fail to use the model inputs proffered by Basin herein, even if Region 8 had broad discretion regarding those model inputs.

However, in this case the discretion resides with North Dakota. Section 101 of the Clean Air Act states:

> . . . Air pollution prevention (that is, the elimination, through any measures, of the amount of pollutants produced or created at the source) and air pollution control at its source, is the primary responsibility of state and local governments. 42 U.S.C. § 7401.

Alabama Power v. Costle, 636 F.2d 323, 361 (D.C. Cir. 1979) ruled that "EPA has authority under the statute to prevent or correct a violation of the [PSD] increments, but *the agency is without authority to dictate to the states their policy for management of the consumption of allowable increments*" (emphasis added) and in *Bethlehem Steel Corp. v. Gorsuch*, 742 F.2d 1028, 1036 (7th Cir. 1984), the court observed that

> The federal government through the EPA determines the ends – the standards of air quality – but Congress has given the states the initiative and a broad responsibility regarding the means to achieve those ends through state implementation plans and time tables for compliance. (citations omitted). *The Clean Air Act is an experiment in federalism, and the EPA may not run roughshod over the procedural prerogatives that the Act has reserved to the states (citations omitted) especially when, as in this case, the agency is overriding state policy.* (Emphasis added).

EPA has approved the North Dakota SIP provision respecting the PSD program and the state, under this "experiment in federalism," has primary responsibility and authority to administer the program. Respecting modeling issues, EPA's *Guideline on*

Air Quality Models recognizes that for meteorological phenomena, "case-by-case analysis and judgment are frequently required" (40 C.F.R. Part 51, App. W., Section 1.0.c.), and that such judgments are to be made by the "reviewing authority" (*id.* at Section 3.0.b), in this case the State of North Dakota. The exercise of judgment by North Dakota includes the selection of various model inputs that are at issue, *e.g.*, baseline years most representative of normal operations, and baseline emissions.

Congress having conferred on the states the primary responsibility for air pollution prevention, and EPA having approved North Dakota's PSD SIP, including the state's authority as the reviewing authority to protect PSD increments, it would disrupt the federalism balance of the Clean Air Act, dishonor the approval of North Dakota's PSD SIP, and contravene EPA's *Guideline on Air Quality Models*, for Region 8 to seek to dictate to the state how modeling should be performed in this case.

In the administration by a state of its approved SIP, "EPA is to be accorded no discretion in interpreting state law." *Florida Power and Light Company v. Costle*, 650 F.2d 579, 588 (5th Cir. 1981). The EPA "should defer to the state's interpretation of the terms of its air pollution control plan when said interpretation is consistent with the Clean Air Act." *Id.*, quoting *United States v. Interlake, Inc.*, 432 F. Supp. 985, 987 (N.D. Ill. 1977).

In *Florida Power and Light*, the court held that EPA abused its discretion in attempting to graft a two-year limit on the duration of a variance granted by the State of Florida in accordance with the state's SIP. The court found that EPA had acted outside its Congressional mandate in attempting to enforce its interpretation of Florida state law. 650 F.2d at 589.

Likewise, in *United States v. General Motors*, 702 F. Supp. 133 (N.D. Tex. 1988), EPA sought to enforce a SIP provision, although Texas had modified the SIP requirement at issue by approving an alternate method of control ("AMC") for a General Motors plant. Texas' approved SIP conferred on the state the authority to approve AMCs. The court, citing *Florida Light & Power* and *Interlake*, rejected EPA's contention that it retained authority to approve or disapprove an AMC, holding that under the approved Texas SIP the state had authority over AMCs.

In this case, the approved North Dakota PSD SIP authorizes the NDDH to administer the state's approved SIP, including but not limited to provisions incorporating EPA's *Guideline on Air Quality models* and the definition of "actual" emissions authorizing "the department" to decide whether a baseline period other than 1976-77 is "more representative of normal source operation."

It is North Dakota that must apply and interpret these SIP provisions — these requirements of state law. Of course, either EPA or any other interested party may challenge the state's actions and interpretations if they are clearly erroneous. Short of that, however, Region 8 should defer to the state's interpretation of its own SIP.

In this case, because the state's selection of representative baseline years and baseline emissions are well supported by the evidence, EPA may not reject those selections in favor of its own interpretation.

VII. CONCLUSION

Basin submits that both monitored data and proper modeled predictions demonstrate there is no violation of Class I SO_2 increments. Model predictions to the contrary are not supported by the evidence. Region 8 should revise its model inputs consistent with those proposed by Basin, for the reasons noted herein.

Dated: June 30, 2003

RESPECTFULLY SUBMITTED,

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National Park Service
U.S. Department of the Interior

Air Resources Division

Air Quality in the National Parks
Second Edition

ATTACHMENT A

Appendix A
Data Tables

Haziness Index in U.S. National Parks for the Clearest Days, 1990 - 1999: Average of Best 20 percent days, in deciviews (dv)

Haziness Index in U.S. National Parks for the Haziest Days, 1990 -1999: Average of Worst 20 percent days, in deciviews (dv)

Precipitation-Weighted Mean Sulfate Ion Concentration in U.S. National Parks, 1990 - 1999: Annual Average in μeq/liter

Sulfate Ion Wet Deposition in U.S. National Parks, 1990 - 1999: Annual Average in kilograms/hectare

Precipitation-Weighted Mean Nitrate Ion Concentration in U.S. National Parks, 1990 - 1999: Annual Average in μeq/liter

Inorganic Nitrogen Wet Deposition From Nitrate and Ammonium in U.S. National Parks, 1990 -1999: Annual Average in kilograms/hectare

Ozone Levels in U.S. National Parks, 1990 - 1999: Average of the Daily 1-hour Maximum, May-September, in ppb

Ozone Levels in U.S. National Parks, 1990 - 1999: Annual 4th Highest 8-hour Average, in ppb

Haziness Index in U.S. National Parks for the Clearest Days
1990 – 1999: Average of Best 20 percent days, in deciviews (dv)

Park	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg	Status	Trend	Slope, dv/yr
Acadia, ME		10.6	10.7	10.2	10.6	9.8	9.6	9.1	9.7	9.3	8.7	9.8	⊙	↓	-0.20
Badlands, ND		7.6	7.4	7.2	7.4	7.9	6.6	7.9	7.1	7.4	6.6	7.3	○	⇩	-0.07
Bandelier, NM		–	–	–	7	6.7	5.9	6.0	6.3	6.8	6.7	6.5	○	–	+0.00
Big Bend, TX		8.4	8.2	7.5	7.7	8.5	7.8	–	6.9	9.3	8.8	8.1	⊙	–	+0.06
Bryce Canyon, UT		4.9	5.0	5.7	4.8	4.5	4.3	4.1	4.6	4.5	4.7	4.7	●	↓	-0.07
Canyonlands, UT		5.9	6.2	6.3	6	6.5	5.7	4.9	6.0	5.8	5.8	5.9	⊙	↓	-0.04
Chiricahua, AZ		–	6.8	6.6	6.4	6.6	6.8	6.4	6.7	6.6	6.4	6.6	○	⇩	-0.02
Crater Lake, OR		–	–	5.1	5.1	–	3.7	4.3	4.3	4.1	4.1	4.4	●	↓	-0.14
Denali, AK		–	3.5	3.4	3.7	3.4	3.2	3.7	4.1	3.1	3.2	3.5	●	⇩	-0.03
Glacier, MT		8.0	9.8	8.9	9.0	8.5	7.9	8	7.9	8.3	7.5	8.4	⊙	↓	-0.20
Grand Canyon, AZ		–	–	–	5.7	5.3	3.9	4.0	4.4	4.8	5.2	5.1	●	–	+0.00
Great Basin, NV		5.1	5.5	–	5.1	4.9	5.0	5.1	5.0	5.0	5.3	4.8	●	⇩	-0.02
Great Sand Dunes, CO		6.6	6.7	6.3	6.1	5.4	4.8	4.9	5.3	6.6	5.5	5.8	⊙	↓	-0.17
Great Smoky Mts., TN/NC		15.3	13.8	13.6	14.4	13.8	13.5	15.3	15.1	14.4	15.2	14.4	●	⇧	+0.09
Guadalupe Mts., TX		–	–	7.3	8.0	7.5	8.3	7.8	7.2	7.5	7.6	7.7	○	⇩	-0.01
Lassen Volcanic, CA		4.5	4.3	4.7	5.1	4.4	3.9	4.0	4.4	4.3	4.1	4.4	●	↓	-0.06
Mammoth Cave, KY		–	–	16.3	17.3	–	15.5	16	16.8	16.2	16.1	16.3	●	⇩	-0.03
Mesa Verde, CO		5.5	6.1	5.6	5.7	6.3	4.9	5.0	–	5.9	5.7	5.6	⊙	⇧	+0.01
Mt. Rainier, WA		–	7.0	7.2	7.5	6.3	5.0	5.4	5.5	5.0	5.3	6.0	⊙	↓	-0.28
Petrified Forest, AZ		–	8.0	7.6	6.2	6.2	6.2	6.1	6.9	6.8	6.7	6.7	○	⇩	-0.10
Pinnacles, CA		9.4	9.3	9.1	8.7	9.4	8.3	8.0	8.9	–	8.7	8.9	⊙	↓	-0.12
Point Reyes, CA		9.1	8.8	8.6	9.5	8.1	7.9	8.1	–	8.7	8.9	8.6	⊙	⇩	-0.08
Redwood, CA		6.7	6.8	6.9	6.7	6.3	6.6	5.3	6.1	5.5	6.2	6.3	⊙	↓	-0.10
Rocky Mountain, CO		4.3	4.1	3.9	4.5	5.0	4.3	3.9	4.2	4.8	3.9	4.3	●	–	+0.00
Shenandoah, VA		14.1	13.4	12.6	14.2	12.3	12.8	14.2	13.5	11.8	11.9	13.1	●	↓	-0.15
Tonto, AZ		–	8.2	–	7.7	7.2	7.7	7.7	7.6	7.0	8.1	7.7	○	⇩	-0.04
Yellowstone, WY		–	–	5.9	5.2	4.7	4.8	5	–	–	3.8	4.9	●	↓	-0.23
Yosemite, CA		5.4	5.6	4.8	4.8	4.5	5.3	4.6	5.5	4.7	5.0	5.0	●	⇩	-0.02
	Average	7.7	7.5	7.6	7.5	6.9	6.8	6.8	7.2	7.1	7.0	7.2			

Symbols: "–" indicates insufficient or no data, or no trend

Park Air Quality Status		Trend	
Much Worse than NPS Average	●	Significant Improvement**	↓
Worse than NPS Average	⊙	Improvement	⇩
NPS Average	○	Degradation	⇧
Better than NPS Average	⊙	Significant Degradation**	↑
Much Better than NPS Average	●	No Trend	–

**Statistically significant at a=0.15

Haziness Index in U.S. National Parks for the Haziest Days
1990 – 1999: Average of Worst 20 percent days, in deciviews (dv)

Park	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg	Status	Trend	Slope, dv/yr
Acadia, ME		24.9	24.8	26.2	26.2	27.4	23.5	24.0	23.1	23.9	24.2	24.8	◉	↓	-0.15
Badlands, ND		17.9	18.1	18.4	17.3	18.2	17.2	17.3	17.0	19.0	17.1	17.8	○	⇩	-0.09
Bandelier, NM		–	–	–	13.1	12.5	13.0	12.7	13.1	14.4	12.8	13.1	⊙	–	+0.05
Big Bend, TX		16.2	17.1	16.3	16.8	17.4	17.5	–	17.3	20.9	19.3	17.6	○	⇧	+0.35
Bryce Canyon, UT		11.4	11.5	11.2	12.1	11.5	11.1	12.9	12.4	11.5	11.7	11.7	●	–	+0.04
Canyonlands, UT		12.9	14.1	13.2	12.5	11.9	11.2	12.8	11.9	12.2	11.8	12.5	●	↓	-0.17
Chiricahua, AZ		–	13.1	13.2	13.7	14.0	14.1	13.4	12.9	15.1	13.0	13.6	⊙	–	+0.06
Crater Lake, OR		–	–	13.3	13.8	–	12.8	15.6	12.1	13.4	13.5	13.5	⊙	–	+0.02
Denali, AK		–	12.3	9.2	11.2	10.4	9.4	9.5	12.1	8.2	9.3	10.2	●	↓	-0.35
Glacier, MT		19.5	19.6	19.1	19.0	19.6	18.1	17.9	17.4	20.4	19.4	19.0	⊙	⇩	-0.17
Grand Canyon, AZ		13.5	11.7	–	11.9	11.8	11.8	12.1	11.3	12.6	12.1	12.1	●	–	+0.01
Great Basin, NV		–	–	–	12.0	11.4	10.8	12.9	11.0	11.6	11.9	11.7	●	–	+0.05
Great Sand Dunes, CO		13.9	12.7	11.4	12.1	15.3	11.8	12.5	11.9	13.2	12.5	12.7	●	⇩	-0.02
Great Smoky Mts., TN/NC		32.8	29.6	30.7	30.9	31.6	30.6	31.2	30.9	31.8	30.5	31.1	◉	–	+0.00
Guadalupe Mts., TX		–	–	14.7	15.4	16.2	16.2	15.2	16.6	17.8	18.1	16.3	○	↑	+0.46
Lassen Volcanic, CA		13.3	13.0	13.5	13.3	13.6	12.8	13.4	12.1	15.4	20.7	14.1	⊙	–	+0.10
Mammoth Cave, KY		–	–	30.7	31.5	–	30.3	30.5	29.9	30.5	29.6	30.4	◉	↓	-0.16
Mesa Verde, CO		12.6	11.5	11.2	12.0	11.8	11.9	12.7	–	12.2	13.9	12.2	●	–	+0.12
Mt. Rainier, WA		–	21.0	20.7	20.0	20.2	18.7	18.9	18.6	20.3	19.7	19.8	⊙	↓	-0.26
Petrified Forest, AZ		–	13.6	13.0	12.6	12.3	13.0	12.6	12.7	13.7	13.4	13.0	⊙	–	+0.02
Pinnacles, CA		19.5	19.1	19.0	18.3	17.7	18.5	17.9	17.7	–	19.3	18.6	⊙	↓	-0.20
Point Reyes, CA		20.8	21.1	21.1	20.9	20.4	20.2	20.1	–	19.6	21.8	20.7	⊙	↓	-0.15
Redwood, CA		19.7	18.9	19.7	18.0	17.3	18.5	18.0	18.9	16.7	20.1	18.6	⊙	⇩	-0.15
Rocky Mountain, CO		13.9	13.1	13.1	12.9	13.4	13.3	13.3	12.4	13.4	12.4	13.1	⊙	⇩	-0.09
Shenandoah, VA		30.9	32.4	31.3	32.6	31.9	30.4	29.3	29.9	30.3	28.4	30.7	◉	↓	-0.30
Tonto, AZ		–	14.2	–	15.3	13.8	15.2	14.8	14.2	14.9	15.4	14.7	○	⇧	+0.08
Yellowstone, WY		–	–	13.2	11.9	14.8	11.7	14.9	–	–	11.8	13.1	⊙	⇩	-0.02
Yosemite, CA		16.3	16.1	17.3	15.1	16.8	17.5	19.6	15.7	15.7	22.0	17.2	○	⇧	+0.23
	Average	18.2	17.2	17.5	16.9	16.7	16.5	16.9	16.5	17.3	17.3	16.9			

Symbols: "–" indicates insufficient or no data, or no trend

Park Air Quality Status		Trend	
Much Worse than NPS Average	◉	Significant Improvement**	↓
Worse than NPS Average	⊙	Improvement	⇩
NPS Average	○	Degradation	⇧
Better than NPS Average	⊙	Significant Degradation**	↑
Much Better than NPS Average	◉	No Trend	–

**Statistically significant at a=0.15

Precipitation-Weighted Mean Sulfate Ion Concentration in U.S. National Parks
1990 – 1999: Annual Average in μeq/liter

Park	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg	Status	Trend	Slope, μeq/l/yr
Acadia, ME		30.9	24.1	30.9	23.7	23.0	23.1	20.3	29.4	25.1	19.4	25.0	●	↓	-0.72
Bandelier, NM		16.6	13.9	15.4	14.5	13.7	13.4	12.1	16.5	–	14.7	14.5	○	⇩	-0.28
Big Bend, TX		–	16.4	16.6	14.3	27.9	29.6	22.7	22.4	23.4	20.2	21.5	⊙	⇧	+0.76
Bryce Canyon, UT		14.3	–	–	–	14.0	11.9	–	15.2	10.8	9.2	12.5	⊙	↓	-0.56
Buffalo River, AR		–	–	25.9	23.1	20.8	23.5	23.2	24.3	21.9	19.5	22.8	⊙	↓	-0.56
Cape Cod, MA		33.8	–	32.0	31.2	–	31.4	–	–	–	27.1	31.1	◐	–	–
Capulin Volcano, NM		14.8	14.1	16.9	15.1	15.0	13.4	17.8	–	10.1	13.5	14.5	○	↓	-0.26
Craters of the Moon, ID		12.9	11.4	10.7	9.6	8.2	8.6	4.9	6.5	7.2	6.8	8.7	⊙	↓	-0.71
Denali, AK		3.5	4.1	3.8	3.9	3.8	2.5	2.4	3.5	2.3	2.2	3.2	●	↓	-0.14
Everglades, FL		15.2	14.0	–	–	15.8	14.5	15.4	–	16.8	13.4	15.0	○	⇧	+0.04
Gila Cliff Dwellings, NM		21.3	15.6	19.0	20.5	18.4	16.8	18.1	22.8	17.7	19.3	18.9	⊙	⇩	-0.13
Glacier, MT		7.2	7.1	8.1	7.8	7.6	5.4	4.9	7.0	6.1	5.3	6.6	●	↓	-0.22
Grand Canyon, AZ		14.6	–	10.2	10.2	12.4	8.8	11.0	–	9.0	11.5	10.9	⊙	⇩	-0.22
Great Basin, NV		14.8	11.8	16.5	–	12.4	11.0	10.1	14.3	10.1	–	12.6	⊙	↓	-0.51
Great Smoky Mts., TN/NC		32.0	36.1	30.1	33.9	24.3	20.9	25.0	30.2	28.6	24.0	28.5	●	↓	-0.99
Guadalupe Mts., TX		–	13.7	24.1	22.7	26.8	20.1	36.6	23.4	27.9	25.1	24.5	●	↑	+1.14
Indiana Dunes, IN		51.3	59.6	66.8	57.0	48.3	56.2	47.3	47.1	50.1	49.2	53.3	●	↓	-0.98
Isle Royale (Chassell), MI		26.8	25.6	29.9	22.4	21.4	21.0	18.4	16.5	18.9	19.2	22.0	⊙	↓	-1.27
Little Big Horn, MT		16.4	12.7	14.6	13.9	13.8	11.1	12.6	13.3	12.8	10.6	13.2	○	↓	-0.44
Mesa Verde, CO		27.3	21.1	18.7	16.0	21.2	18.1	20.6	16.7	18.6	20.9	19.9	⊙	⇩	-0.28
North Cascades, WA		6.1	6.8	6.3	6.5	–	4.4	5.2	5.0	4.2	4.9	5.5	●	↓	-0.24
Olympic, WA		–	4.5	5.0	5.2	5.0	4.7	–	5.3	4.3	5.7	4.9	●	⇧	+0.07
Organ Pipe Cactus, AZ		16.8	16.9	10.8	7.6	11.9	16.6	28.5	16.8	–	14.5	15.6	○	⇧	+0.09
Rocky Mountain, CO		13.7	14.6	14.8	11.5	16.1	12.8	13.1	10.5	13.5	11.6	13.2	○	↓	-0.25
Sequoia, CA		10.2	5.7	8.0	5.2	5.2	3.9	2.4	2.9	4.9	–	5.4	●	↓	-0.66
Shenandoah, VA		31.2	34.5	23.0	30.9	29.2	–	28.4	29.3	–	27.7	29.3	●	↓	-0.39
Theo. Roosevelt, ND		24.0	16.8	18.4	17.3	20.0	16.7	15.8	–	–	14.7	18.0	⊙	↓	-0.54
Yellowstone, WY		12.0	11.0	8.1	8.6	9.7	5.8	4.8	6.9	6.7	7.2	8.1	⊙	↓	-0.57
Yosemite, CA		–	5.2	3.5	–	4.5	2.7	2.3	2.8	4.6	3.6	3.6	●	⇩	-0.16
	Average	19.5	16.7	18.1	17.3	16.7	15.3	16.3	16.2	14.8	15.6	16.7			

Symbols:

"–" indicates insufficient or no data

Park Air Quality Status		Trend	
Much Worse than NPS Average	●	Significant Improvement**	↓
Worse than NPS Average	⊙	Improvement	⇩
NPS Average	○	Degradation	⇧
Better than NPS Average	⊙	Significant Degradation**	↑
Much Better than NPS Average	●	No Trend	–

**Statistically significant at a=0.15

Sulfate Ion Wet Deposition in U.S. National Parks
1990 – 1999: Annual Average in kilograms/hectare

Park	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg	Status	Trend	Slope, Kg/ha/yr
Acadia, ME		22.7	16.5	18.1	16.9	15.9	16.5	15.0	16.2	17.7	12.5	16.8	●	↓	-0.51
Bandelier, NM		3.2	3.7	2.6	3.3	2.9	2.1	2.0	4.0	–	2.8	3.0	○	⇩	-0.09
Big Bend, TX		–	3.9	3.0	2.3	3.2	3.1	3.0	3.2	2.7	2.1	3.0	○	↓	-0.14
Bryce Canyon, UT		2.4	–	–	–	2.2	2.2	–	3.3	2.7	1.5	2.4	⊙	⇩	-0.04
Buffalo River, AR		–	–	12.7	13.0	12.1	11.3	13.1	10.1	10.8	8.9	11.5	⊙	↓	-0.56
Cape Cod, MA		16.3	–	16.4	19.6	–	16.4	–	–	–	13.5	16.4	●	–	–
Capulin Volcano, NM		3.3	3.9	3.8	4.1	3.4	3.8	4.3	–	2.3	3.5	3.6	○	⇩	-0.03
Craters of the Moon, ID		1.8	1.7	1.0	2.0	0.9	1.9	0.8	1.0	1.6	0.7	1.3	●	↓	-0.08
Denali, AK		1.1	0.8	0.7	0.7	0.6	0.4	0.4	0.6	0.4	0.4	0.6	●	↓	-0.06
Everglades, FL		9.1	10.8	–	–	13.0	12.1	9.2	–	13.3	9.9	11.1	⊙	⇧	+0.09
Gila Cliff Dwellings, NM		3.8	3.3	4.3	4.6	3.4	2.5	3.2	4.7	2.4	2.7	3.5	○	↓	-0.12
Glacier, MT		3.9	2.4	2.8	3.1	2.5	2.7	2.7	2.4	2.3	1.7	2.6	○	↓	-0.15
Grand Canyon, AZ		3.0	–	2.2	2.1	1.8	2.1	1.7	–	1.9	1.9	2.1	⊙	↓	-0.06
Great Basin, NV		2.7	1.9	1.8	–	2.1	2.0	1.8	2.6	1.9	–	2.1	⊙	⇩	-0.01
Great Smoky Mts., TN/NC		24.7	28.0	22.2	25.9	22.4	14.5	23.6	27.2	22.4	16.7	22.8	●	↓	-0.72
Guadalupe Mts., TX		–	4.2	5.7	4.0	4.0	4.0	8.5	4.6	4.8	4.7	4.9	⊙	⇧	+0.06
Indiana Dunes, IN		34.4	28.1	25.1	33.7	19.5	22.7	25.6	20.4	23.6	17.6	25.1	●	↓	-1.31
Isle Royale (Chassell), MI		10.5	11.0	10.1	7.8	6.9	8.9	7.8	5.4	6.5	8.0	8.3	⊙	↓	-0.52
Little Big Horn, MT		2.2	2.1	2.4	2.3	1.9	1.8	1.8	2.0	2.1	1.5	2.0	⊙	↓	-0.07
Mesa Verde, CO		5.6	5.0	4.5	4.0	4.7	3.7	4.5	4.1	3.8	2.9	4.3	⊙	↓	-0.22
North Cascades, WA		8.4	6.3	5.1	4.8	–	5.0	5.6	6.4	3.9	5.5	5.7	⊙	⇩	-0.20
Olympic, WA		–	7.2	7.1	6.1	8.2	6.9	–	10.9	8.1	11.5	8.3	⊙	↑	+0.42
Organ Pipe Cactus, AZ		2.6	1.7	2.2	1.1	1.7	1.6	2.0	1.8	–	1.5	1.8	●	⇩	-0.08
Rocky Mountain, CO		3.1	2.7	2.6	2.3	2.7	3.3	2.3	2.5	2.8	3.0	2.7	○	⇧	+0.01
Sequoia, CA		2.6	1.9	2.8	2.8	2.1	2.9	1.8	1.2	3.6	–	2.4	⊙	⇧	+0.02
Shenandoah, VA		23.6	17.8	18.7	22.4	19.3	–	23.4	17.8	–	18.8	20.2	●	⇩	-0.07
Theo. Roosevelt, ND		3.5	2.9	2.8	3.8	4.2	3.9	2.8	–	–	2.1	3.3	○	⇩	-0.09
Yellowstone, WY		2.1	2.4	1.8	1.6	1.7	1.1	1.0	1.6	1.1	1.3	1.6	●	↓	-0.12
Yosemite, CA		–	2.5	1.5	–	1.8	2.5	2.1	0.9	3.8	1.7	2.1	⊙	⇩	-0.01
	Average	8.2	7.4	6.8	7.5	6.6	6.2	6.9	6.9	6.5	5.7	6.7			

Symbols: "–" indicates insufficient or no data, or no trend

Park Air Quality Status		Trend	
Much Worse than NPS Average	●	Significant Improvement**	↓
Worse than NPS Average	⊙	Improvement	⇩
NPS Average	○	Degradation	⇧
Better than NPS Average	⊙	Significant Degradation**	↑
Much Better than NPS Average	●	No Trend	–

**Statistically significant at a=0.15

Precipitation-Weighted Mean Nitrate Ion Concentration in U.S. National Parks
1990 – 1999: Annual Average in µeq/liter

Park	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg	Status	Trend	Slope, µeq/l/yr
Acadia, ME		15.3	11.1	16.4	12.3	10.2	11.5	11.3	15.9	12.7	10.8	12.7	⊙	⇩	-0.19
Bandelier, NM		12.5	12.2	12.3	12.2	13.8	16.7	11.6	17.0	–	17.4	14.0	○	⇧	+0.60
Big Bend, TX		–	10.3	10.2	10.7	17.7	15.5	13.5	13.3	16.8	13.1	13.5	○	⇧	+0.47
Bryce Canyon, UT		15.4	–	–	–	14.1	10.7	–	15.4	11.4	15.0	13.7	○	⇩	-0.04
Buffalo River, AR		–	–	14.2	14.1	12.4	14.4	14.8	15.4	13.8	13.2	14.0	○	–	0.00
Cape Cod, MA		15.2	–	17.2	13.6	–	19.5	–	–	–	13.4	15.8	⊙	–	–
Capulin Volcano, NM		13.5	12.7	15.8	14.9	16.4	14.0	17.5	–	12.1	15.1	14.7	⊙	⇧	+0.23
Craters of the Moon, ID		9.8	11.6	12.5	9.8	14.3	10.7	6.8	11.1	11.5	10.7	10.9	⊙	–	0.00
Denali, AK		1.8	4.2	2.3	2.4	2.8	1.4	1.4	3.3	1.3	2.0	2.3	●	⇩	-0.07
Everglades, FL		9.6	8.4	–	–	9.3	8.2	8.5	–	8.4	8.0	8.6	⊙	↓	-0.15
Gila Cliff Dwellings, NM		12.9	9.3	9.9	11.2	12.2	11.8	14.2	13.5	12.6	17.1	12.5	⊙	↑	+0.64
Glacier, MT		5.8	6.3	6.8	6.3	7.4	5.1	5.7	7.7	5.9	5.7	6.3	●	⇩	-0.01
Grand Canyon, AZ		16.9	–	11.9	10.7	15.9	10.4	15.0	–	10.2	18.5	13.7	○	⇩	-0.11
Great Basin, NV		20.0	15.2	19.9	–	16.9	12.2	14.7	17.6	15.1	–	16.4	⊙	↓	-0.46
Great Smoky Mts., TN/NC		13.3	14.1	14.9	15.8	12.1	13.2	13.2	15.3	15.4	13.0	14.0	○	⇧	+0.03
Guadalupe Mts., TX		–	8.7	15.1	13.6	18.0	14.2	11.8	14.4	15.5	18.2	14.4	⊙	↑	+0.54
Indiana Dunes, IN		21.6	29.4	31.2	26.3	28.2	33.3	26.7	29.7	27.6	28.3	28.2	●	⇧	+0.26
Isle Royale (Chassell), MI		16.7	17.0	18.2	16.5	19.2	18.5	17.6	17.4	17.2	17.8	17.6	●	⇧	+0.08
Little Big Horn, MT		13.1	11.4	10.8	10.9	11.8	10.2	13.6	14.9	14.8	12.7	12.4	⊙	↑	+0.25
Mesa Verde, CO		19.4	14.3	14.1	11.9	17.8	14.1	19.5	15.4	14.7	21.9	16.3	⊙	⇧	+0.23
North Cascades, WA		4.9	5.0	5.2	5.7	–	3.8	4.9	4.8	4.3	4.6	4.8	●	↓	-0.06
Olympic, WA		–	1.6	1.6	1.8	1.5	1.8	–	1.8	1.3	1.2	1.6	●	⇩	-0.04
Organ Pipe Cactus, AZ		15.8	11.6	9.4	4.5	8.2	12.8	23.1	14.4	–	19.0	13.2	○	⇧	+0.97
Rocky Mountain, CO		15.8	16.3	17.1	14.2	20.9	16.5	17.2	15.1	18.7	16.7	16.8	●	⇧	+0.15
Sequoia, CA		22.0	8.4	13.0	7.6	11.2	6.3	3.4	6.7	8.2	–	9.6	⊙	↓	-0.96
Shenandoah, VA		12.9	15.0	10.0	13.2	14.1	–	15.9	14.7	–	12.7	13.6	○	⇧	+0.19
Theo. Roosevelt, ND		14.2	14.7	13.3	12.1	16.1	15.0	15.7	–	–	14.6	14.4	⊙	⇧	+0.17
Yellowstone, WY		11.6	9.7	8.5	8.1	10.3	7.7	6.7	9.5	8.1	9.7	9.0	⊙	⇩	-0.23
Yosemite, CA		–	6.8	6.1	–	7.8	4.0	2.8	5.7	9.6	7.5	6.3	●	⇧	+0.14
	Average	13.7	11.4	12.5	11.1	13.1	11.9	12.6	13.5	12.4	13.2	12.5			

Symbols:

"–" indicates insufficient or no data

Park Air Quality Status		Trend	
Much Worse than NPS Average	●	Significant Improvement**	↓
Worse than NPS Average	⊙	Improvement	⇩
NPS Average	○	Degradation	⇧
Better than NPS Average	⊙	Significant Degradation**	↑
Much Better than NPS Average	●	No Trend	–

**Statistically significant at a=0.15

Inorganic Nitrogen Wet Deposition From Nitrate and Ammonium in U.S. National Parks
1990 – 1999: Annual Average in kilograms/hectare

Park	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg	Status	Trend	Slope, Kg/ha/yr
Acadia, ME		4.9	3.1	4.2	3.6	3.3	3.7	3.7	3.8	3.6	2.9	3.7	⊙	⇩	-0.08
Bandelier, NM		1.3	1.5	1.1	1.3	1.4	1.3	1.1	2.0	–	1.5	1.4	○	⇧	+0.03
Big Bend, TX		–	1.4	1.1	1.0	1.2	1.2	1.2	1.1	1.3	0.8	1.1	○	⇩	-0.04
Bryce Canyon, UT		1.3	–	–	–	1.0	0.9	–	1.6	1.2	1.1	1.2	○	⇩	-0.01
Buffalo River, AR		–	–	3.6	4.0	3.8	4.2	4.7	3.2	3.9	3.2	3.8	◉	⇩	-0.04
Cape Cod, MA		3.1	–	3.5	3.5	–	4.4	–	–	–	2.7	3.4	⊙	–	–
Capulin Volcano, NM		1.9	2.0	2.3	2.2	2.1	2.3	2.5	–	1.5	2.4	2.1	○	↑	+0.05
Craters of the Moon, ID		0.9	1.2	0.8	1.2	0.9	1.4	0.7	1.0	1.5	0.8	1.0	⊙	–	0.00
Denali, AK		0.3	0.6	0.2	0.2	0.2	0.1	0.1	0.3	0.1	0.2	0.2	●	↓	-0.02
Everglades, FL		3.0	2.6	–	–	4.0	3.4	2.4	–	4.1	2.8	3.2	⊙	⇧	+0.03
Gila Cliff Dwellings, NM		1.2	0.9	1.2	1.2	1.0	0.9	1.3	1.3	0.8	1.1	1.1	⊙	⇩	-0.01
Glacier, MT		1.7	0.9	1.2	1.3	1.2	1.4	1.4	1.2	1.0	0.9	1.2	○	⇩	-0.04
Grand Canyon, AZ		1.7	–	1.2	1.0	1.1	1.3	1.0	–	1.0	1.5	1.2	○	⇩	-0.02
Great Basin, NV		1.9	1.2	1.2	–	1.5	1.2	1.4	1.7	1.4	–	1.4	○	–	0.00
Great Smoky Mts., TN/NC		5.4	5.4	4.7	5.6	5.5	4.6	5.8	6.7	5.9	4.3	5.4	◉	⇧	+0.07
Guadalupe Mts., TX		–	1.4	2.0	1.5	1.7	1.8	1.6	1.6	1.6	2.0	1.7	○	⇧	+0.01
Indiana Dunes, IN		8.0	7.4	6.3	8.3	6.2	7.4	8.4	6.5	7.1	5.3	7.1	●	↓	-0.14
Isle Royale (Chassell), MI		4.1	3.9	3.4	3.1	3.4	4.4	4.0	3.0	3.3	3.9	3.7	⊙	⇩	-0.02
Little Big Horn, MT		1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.2	1.3	1.1	1.1	⊙	↑	+0.02
Mesa Verde, CO		1.7	1.4	1.6	1.3	1.7	1.4	2.1	1.6	1.3	1.3	1.5	○	↓	-0.02
North Cascades, WA		3.2	1.8	1.6	1.8	–	1.8	2.4	2.4	1.4	1.9	2.0	○	⇩	-0.01
Olympic, WA		–	1.0	1.0	1.1	1.2	1.3	–	1.5	1.0	1.3	1.2	○	↑	+0.05
Organ Pipe Cactus, AZ		1.6	0.6	1.1	0.4	0.6	0.7	0.8	0.7	1.2	1.1	0.9	●	⇧	+0.02
Rocky Mountain, CO		2.0	1.6	1.7	1.6	1.8	2.2	1.7	1.8	2.1	2.4	1.9	○	↑	+0.07
Sequoia, CA		3.7	1.8	3.7	2.9	2.9	3.1	1.7	1.6	4.3	–	2.8	⊙	⇩	-0.06
Shenandoah, VA		5.3	4.1	4.3	5.1	5.0	–	6.6	4.6	–	4.6	4.9	◉	⇧	-0.02
Theo. Roosevelt, ND		1.5	1.5	1.3	1.6	2.2	2.5	1.9	–	–	1.3	1.7	○	⇧	+0.05
Yellowstone, WY		1.1	1.1	1.1	0.9	1.0	0.8	0.8	1.1	0.7	1.0	1.0	●	↓	-0.02
Yosemite, CA		–	1.6	1.5	–	1.7	2.3	1.4	1.0	5.0	2.3	2.1	⊙	⇧	0.08
	Average	2.6	2.0	2.1	2.3	2.2	2.2	2.4	2.2	2.4	2.1	2.2			

Symbols: "–" indicates insufficient or no data, or no trend

Park Air Quality Status		Trend	
Much Worse than NPS Average	●	Significant Improvement**	↓
Worse than NPS Average	⊙	Improvement	⇩
NPS Average	○	Degradation	⇧
Better than NPS Average	⊙	Significant Degradation**	↑
Much Better than NPS Average	●	No Trend	–

**Statistically significant at a=0.15

Ozone Levels in U.S. National Parks
1990 – 1999: Average of the Daily 1-hour Maximum, May–September, in ppb

Park	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg	Status	Trend	Slope, ppb/yr
Acadia, ME		50	52	47	46	49	49	40	45	57	53	49	⊙	↘	-0.1
Big Bend, TX		–	–	47	47	56	–	46	46	52	45	49	⊙	↓	-0.3
Canyonlands, UT		–	–	–	55	58	56	63	56	61	62	59	◔	↑	+0.7
Cape Cod, MA		55	64	56	54	57	56	57	64	58	55	57	○	↗	+0.3
Chamizal, TX		–	–	54	44	–	60	55	58	–	58	55	○	→	+0.9
Chiricahua, AZ		55	55	54	56	59	–	57	54	57	55	56	○	→	+0.2
Channel Islands, CA		–	–	55	–	–	–	49	44	47	45	48	⊙	–	–
Congaree Swamp, SC		64	–	42	51	42	54	53	49	63	61	53	○	↗	+1.7
Cowpens, SC		59	60	62	68	62	63	64	70	73	68	65	◔	↑	+1.2
Craters of the Moon, ID		–	–	–	48	57	51	56	51	56	57	54	○	↑	+1.3
Denali, AK		32	32	32	32	32	31	33	33	34	34	32	●	↑	+0.2
Death Valley, CA		–	–	–	–	67	–	62	61	66	67	65	◔	–	–
Everglades, FL		32	29	–	30	–	31	29	28	35	35	31	●	↗	+0.3
Glacier, MT		44	43	42	36	45	38	45	33	45	42	41	⊙	⇩	-0.2
Grand Canyon, AZ		51	52	51	53	56	59	60	57	60	58	56	○	↑	+1.1
Great Basin, NV		–	–	–	–	56	54	59	56	58	59	57	○	↑	+1.0
Great Smoky Mts., TN/NC		67	61	59	69	66	–	71	72	77	78	69	◕	↑	+1.9
Joshua Tree, CA		74	83	85	–	94	84	89	85	76	82	84	◕	↗	+0.04
Lassen Volcanic, CA		54	53	53	51	62	55	59	52	57	63	56	○	↑	+0.6
Mammoth Cave, KY		60	56	53	55	60	64	64	60	70	–	60	◔	↑	+1.4
Mesa Verde, CO		–	–	–	–	54	54	56	53	58	58	56	○	↑	+1.0
Mount Rainier, WA		–	–	–	37	45	41	41	28	28	40	37	●	⇩	-1.1
Olympic, WA		29	29	30	28	29	32	32	27	29	28	29	●	⇩	-0.1
Pinnacles, CA		64	66	65	64	63	65	70	63	63	63	65	⊙	↓	-0.2
Rocky Mountain, CO		47	56	57	59	62	59	62	58	63	58	58	⊙	↑	+1.0
Saguaro, AZ		62	62	63	65	69	65	60	65	65	60	64	⊙	⇩	-0.02
Sequoia, CA		79	76	83	85	86	73	84	75	74	79	79	◕	⇩	-0.3
Shenandoah, VA		62	68	60	64	62	67	64	63	74	71	66	⊙	↑	+0.9
Theo. Roosevelt, ND		46	48	45	42	47	47	49	50	–	47	47	⊙	⇧	+0.3
Voyageurs, MN		34	34	39	36	39	43	44	45	44	40	40	⊙	↑	+1.2
Yellowstone, WY		38	47	47	46	53	51	52	49	52	56	49	⊙	↑	+1.1
Yosemite, CA		–	–	–	–	74	69	73	61	70	71	70	◕	⇩	-0.6
	Average	53	54	53	51	57	54	56	53	57	56	55			

Symbols: "–" indicates insufficient or no data, or no trend

Park Air Quality Status		Trend	
Much Worse than NPS Average	●	Significant Improvement**	↓
Worse than NPS Average	⊙	Improvement	⇩
NPS Average	○	Degradation	⇧
Better than NPS Average	⊙	Significant Degradation**	↑
Much Better than NPS Average	●	No Trend	–

**Statistically significant at a=0.15

Ozone Levels in U.S. National Parks
1990 – 1999: Annual 4th Highest 8-hour Average, in ppb

Park	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg	Status	Trend	Slope ppb/yr
Acadia, ME		[illegible]	[illegible]	80	80	74	[illegible]	73	77	[illegible]	[illegible]	84	[illegible]	[illegible]	-0.7
Big Bend, TX		–	57	61	63	69	65	73	63	70	64	65	⊙	↑	+1.2
Canyonlands, UT		–	–	60	63	68	63	74	67	71	73	67	⊙	↑	+1.8
Cape Cod, MA		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	●	⇩	-0.5
Chamizal, TX		–	–	72	59	75	84	78	71	[illegible]	71	75	○	[illegible]	+1.5
Chiricahua, AZ		69	71	65	68	71	69	72	65	67	72	69	○	[illegible]	+0.1
Channel Islands, CA		56	80	81	–	–	–	75	63	66	69	70	○	⇩	-1.0
Congaree Swamp, SC		[illegible]	59	66	62	64	76	74	65	81	80	72	○	↑	+1.7
Cowpens, SC		74	77	85	82	82	84	80	[illegible]	[illegible]	[illegible]	84	[illegible]	↑	+2.0
Craters of the Moon, ID		–	–	42	55	63	57	64	60	65	68	59	●	↑	
Denali, AK		48	49	50	48	49	53	53	51	54	54	51	●	↑	+0.7
Death Valley, CA		–	–	–	–	84	67	78	77	82	79	78	[illegible]	[illegible]	+0.3
Everglades, FL		60	58	61	64	64	58	63	66	72	67	63	⊙	↑	+1.0
Glacier, MT		50	51	51	44	55	43	57	40	53	50	49	●	–	+0.0
Grand Canyon, AZ		65	72	68	64	69	69	73	72	72	76	70	○	↑	+1.0
Great Basin, NV		–	–	–	51	69	67	74	74	70	72	68	○	↑	+1.7
Great Smoky Mts., TN/NC		[illegible]	79	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	◐	↑	+2.6
Joshua Tree, CA		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	◐	[illegible]	+0.8
Lassen Volcanic, CA		78	66	66	64	78	74	73	67	78	84	73	○	↑	+1.2
Mammoth Cave, KY		83	78	73	72	75	[illegible]	82	85	[illegible]	[illegible]	83	⊙	↑	+2.5
Mesa Verde, CO		–	–	–	58	62	63	72	62	68	69	65	⊙	↑	+1.5
Mount Rainier, WA		–	–	–	55	67	65	65	40	51	64	58	●	⇩	-0.6
Olympic, WA		46	41	46	42	41	44	46	45	41	43	44	●	–	+0.0
Pinnacles, CA		83	84	84	82	78	83	[illegible]	76	[illegible]	82	83	⊙	⇩	-0.1
Rocky Mountain, CO		57	76	71	71	76	76	72	70	80	74	72	○	⇧	+0.5
Saguaro, AZ		75	73	74	82	80	83	76	79	76	69	77	⊙	–	+0.0
Sequoia, CA		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	◐	⇩	-0.2
Shenandoah, VA		[illegible]	83	77	83	83	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	◐	↑	+1.5
Theo. Roosevelt, ND		62	60	57	55	57	58	59	71	56	58	59	●	⇩	-0.2
Voyageurs, MN		52	50	63	58	60	70	67	71	67	74	63	⊙	↑	+2.4
Yellowstone, WY		54	57	63	53	61	60	61	61	66	70	61	⊙	↑	+1.3
Yosemite, CA		78	[illegible]	[illegible]	–	[illegible]	[illegible]	[illegible]	81	[illegible]	85	[illegible]	◐	⇩	-1.7
	Average	72	73	71	67	73	74	75	72	77	77	73			

Symbols:

Numbers in RED exceed national ambient air quality standard
"–" indicates insufficient or no data, or no trend

Park Air Quality Status		Trend	
Much Worse than NPS Average	●	Significant Improvement**	⇩
Worse than NPS Average	⊙	Improvement	⇩
NPS Average	○	Degradation	⇧
Better than NPS Average	⊙	Significant Degradation**	↑
Much Better than NPS Average	●	No Trend	–

**Statistically significant at a=0.15